

Anne M. Van Leeuwen

Debra J. Poelhuis-Leth

Davis's

**Comprehensive Handbook of
Laboratory and
Diagnostic Tests with
Nursing Implications**

THIRD EDITION



Davis's

**Comprehensive Handbook *of*
Laboratory and
Diagnostic Tests—with
Nursing Implications**

Anne M. Van Leeuwen, MA, BS, MT (ASCP)

Debra J. Poelhuis-Leth, MS, RT (R)(M)

With special considerations by

Marijke Vroomen-Durning, RN

Davis's

**Comprehensive Handbook of
Laboratory and
Diagnostic Tests—with
Nursing Implications**

THIRD EDITION



E. A. DAVIS COMPANY • Philadelphia

F. A. Davis Company
1915 Arch Street
Philadelphia
PA 19103

www.fadavis.com

Copyright © 2009 by F. A. Davis Company
All rights reserved. This book is protected by copyright. No part of it may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without written permission from the publisher.

Printed in the United States of America

Last digit indicates print number: 10 9 8 7 6 5 4 3 2 1

Publisher: Lisa B. Deitch
Art and Design Manager: Carolyn O'Brien
Managing Editor: David Orzechowski
Project Editor: Christina C. Burns

As new scientific information becomes available through basic and clinical research, recommended treatments and drug therapies undergo changes. The authors and publisher have done everything possible to make this book accurate, up to date, and in accord with accepted standards at the time of publication. The authors, editors, and publisher are not responsible for errors or omissions or for consequences from application of the book, and make no warranty, expressed or implied, in regard to the contents of the book. Any practice described in this book should be applied by the reader in accordance with professional standards of care used in regard to the unique circumstances that may apply in each situation. The reader is advised always to check product information (package inserts) for changes and new information regarding dose and contraindications before administering any drug. Caution is especially urged when using new or infrequently ordered drugs.

Library of Congress Cataloging-in-Publication Data

Van Leeuwen, Anne M.
Davis's comprehensive handbook of laboratory and diagnostic tests : with nursing implications / Anne M. Van Leeuwen, Debra Poelhuis-Leth.—3rd ed.
p. ; cm.

Includes bibliographical references and index.

ISBN-13: 978-0-8036-1826-8

ISBN-10: 0-8036-1826-3

1. Diagnosis, Laboratory—Handbooks, manuals, etc. 2. Nursing—Handbooks, manuals, etc. I. Poelhuis-Leth, Debra J. II. Title. III. Title: Comprehensive handbook of laboratory and diagnostic tests.

[DNLM: 1. Laboratory Techniques and Procedures—Handbooks. 2. Laboratory Techniques and Procedures—Nurses' Instruction. 3. Nursing Diagnosis—methods. 4. Diagnostic Techniques and Procedures—Handbooks. 5. Diagnostic Techniques and Procedures—Nurses' Instruction. QY 39 V217d 2009]

RB38.2.S37 2009

616.075—dc22

2008030782

Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by F. A. Davis Company for users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the fee of \$.25 per copy is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923. For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Service is: 8036-1826/09 0 + \$.25

Dedication

Inspiration springs from Passion.... Passion is born from unconstrained love, commitment, and a vision no one else can own.

Lynda, thank you—I could not have done this without your love, strong support, and belief in me. My gratitude to Mom, Dad, Adele, Gram...all my family and friends, for I am truly blessed by your humor and faith. A huge hug for my daughters, Sarah and Margaret—I love you very much. To my puppies, Maggie, Taylor, and Emma for their endless and unconditional love. My thanks and welcome to Debra Poelhuis-Leth for her contributions to this third edition. And, very special thanks to Lisa Deitch, Publisher, for her friendship, excellent direction, and unwavering encouragement.

Anne M. Van Leeuwen, MA, BS, MT (ASCP)

Director of Laboratory Services
Highlands Regional Medical Center
Sebring, Florida

To my husband, Bill, who encouraged and supported me during this new adventure. To my beautiful children, Abbie and Andy, the lights of my life, please remember to always push yourselves to excel. Thanks Mom and Dad for always showing your pride in my endeavors. Anne, Lynette, Lisa, and Rob, your confidence in my abilities and your continued support, guidance, and assistance is greatly appreciated. I look forward to our continued relationship. And lastly, my thanks to Arlene Adler for recommending me for this awesome experience.

Debra J. Poelhuis-Leth, MS, RT, (R)(M)

Director, Radiology Program
Montgomery County Community College
Pottstown, Pennsylvania

About This Book

The authors would like to thank all the users of the previous editions for helping us identify what they like about this book as well as what might improve its value. We want to continue this dialogue. As writers, it is our desire to capture the interest of our readers, to provide essential information, and to continue to improve the presentation of the material in the book and ancillary products. We encourage our readers to provide feedback to the Web site and to the company's sales professionals. Your feedback helps us modify the material—to change with your changing needs. Several new monographs have been added: urea breath test, anti-cyclic citrullinated peptide antibodies, and fluorodeoxyglucose PET scan. Monographs have been expanded to include additional information, for example: US OB biophysical profile, amniotic fluid analysis, and creatinine/eGFR. Some monographs have been combined to consolidate similar tests and a few less frequently used tests have been condensed into a mini-monograph format that highlights abbreviated test-specific facts, with the full monographs for those tests now resident on the DavisPlus Web site (<http://davisplus.fadavis.com>). The names of some test monographs have been changed to assist the reader in locating them more easily. For example, the tests that relate to the complete blood count have been renamed to begin with CBC, “test name” (CBC, hemaglobin; CBC, red blood cell count; etc.), so they are grouped together alphabetically in the text; the individual tests are also listed separately under their own names in the index. All of these changes have been made in response to feedback from our readers.

The authors have taken care to especially enhance four areas in this new edition: pathophysiology that affects test results, patient safety, patient education, and integration of related laboratory and diagnostic testing. First, the result section has been expanded to include an explanation of increased or decreased values, as many of you requested. Second, the authors appreciate that nurses are the strongest patient advocates with a huge responsibility to protect the safety of their patients, and we have observed student nurses in clinical settings being interviewed by facility accreditation inspectors, so we have integrated a number of reminders that parallel the Joint Commission's national patient safety goals. The pretest section reminds the nurse to positively identify the patient before beginning a procedure, administering medications, etc. The pretest section also addresses hand-off communication of critical information. The third area of emphasis is that each monograph coaches the student to focus on patient education and prepares the nurse to anticipate and respond to a patient's questions or concerns; from describing the purpose of the procedure, addressing concerns about pain, understanding the implications of the test results, and describing postprocedural care. Various related Web sites for patient education have been included throughout the book. And fourth, laboratory and diagnostic tests do not stand on their own—all the pieces fit together to form a picture. The section at the end of each monograph that lists related tests by modality has been changed to integrate both laboratory and diagnostic tests. The authors thought it might be more useful for a nurse to know what other tests might be ordered together—and all the related tests are listed alphabetically for ease of use.

To make sure that we remain on target with each revision, we submit the manuscript to a thorough review process. Our reviewers look at the manuscript from both the nursing perspective and the technical perspective, and the insights they provide help mold every edition, but this edition's review was particularly extensive and rigorous. To see the full list of reviewers who participated in the process, go to <http://davisplus.fadavis.com>.

Now—more about the details of this book—laboratory and diagnostic studies are essential components of a complete patient assessment. Examined in conjunction with an individual's history and physical examination, laboratory and diagnostic data provide clues about health status. Nurses are increasingly expected to integrate an understanding of laboratory and diagnostic procedures and expected outcomes in assessment, planning, implementation, and evaluation of nursing care. The data help develop and support nursing diagnoses, interventions, and outcomes.

Nurses may interface with laboratory and diagnostic testing on several levels, including:

- Interacting with patients and families of patients undergoing diagnostic tests or procedures, and providing pretest, intratest, and post-test information and support
- Maintaining quality control to prevent or eliminate problems that may interfere with the accuracy and reliability of test results
- Ensuring completion of testing in a timely and accurate manner
- Collaborating with other health care professionals in interpreting findings as they relate to planning and implementing total patient care
- Communicating significant alterations in test outcomes to other appropriate health care team members
- Coordinating interdisciplinary efforts

Whether the nurse's role at each level is direct or indirect, the underlying responsibility to the patient, family, and community remains the same.

This book is a reference for nurses, nursing students, and other health care professionals. It is useful as a clinical tool as well as a supportive text to supplement clinical courses. It guides the nurse in planning what needs to be assessed, monitored, treated, and taught regarding pretest requirements, intratest procedures, and post-test care. It can be used by nursing students at all levels as a textbook in theory classes, integrating laboratory and diagnostic data as one aspect of nursing care; by practicing nurses, to update information; and in clinical settings as a quick reference. Designed for use in academic and clinical settings, *Davis's Comprehensive Handbook of Laboratory and Diagnostic Tests—with Nursing Implications* provides the user with a comprehensive reference that allows easy access to information about laboratory and diagnostic tests and procedures. A general overview of how all the tests and procedures included in this book relate to body systems can be found in tables at the end of the monographs. The tests and procedures are presented in this book in alphabetical order by their complete name, allowing the user to locate information quickly without having to first place tests in a specific category or body system. Each monograph is presented in a consistent format for easy identification of specific information at a glance. The following information is provided for each laboratory and diagnostic test:

- *Test Name* for each monograph is given as a commonly used designation, and all test monographs in the book are organized in alphabetical order by name.

- *Synonyms/Acronyms* for each test are listed where appropriate.
- *Specimen Type* includes the amount of specimen usually collected and, where appropriate, the type of collection tube or container commonly recommended. Specimen requirements vary from laboratory to laboratory. The amount of specimen collected is usually more than what is minimally required so that additional specimen is available, if needed, for repeat testing (quality control failure, dilutions, or confirmation of unexpected results). In the case of diagnostic tests, the *type* of procedure (e.g., nuclear medicine, x-ray) is given.
- *Reference Values* for each monograph include age-specific and gender-specific variations, when indicated. It is important to give consideration to the normal variation of laboratory values over the life span and across cultures; sometimes what might be considered an abnormal value in one circumstance is actually what is expected in another. Reference values for laboratory tests are given in conventional and standard international (SI) units. The factor used to convert conventional to SI units is also given. Because laboratory values can vary by method, each laboratory reference range is listed along with the associated methodology.
- *Description & Rationale* of the study's purpose and insight into how and why the test results can affect health are included.
- *Indications* are a list of what the test is used for in terms of assessment, evaluation, monitoring, screening, identifying, or assisting in the diagnosis of a clinical condition.
- *Results* present a list of conditions in which values may be increased or decreased and, in some cases, an explanation of variations that may be encountered.
- *Critical Values*, or findings that may be life-threatening or for which particular concern may be indicated, are given along with age span considerations where applicable. This section also includes signs and symptoms associated with a critical value as well as possible nursing interventions.
- *Interfering Factors* are substances or circumstances that may influence the results of the test, rendering the results invalid or unreliable. Knowledge of interfering factors is an important aspect of quality assurance and includes pharmaceuticals, foods, natural and additive therapies, timing of test in relation to other tests or procedures, collection site, handling of specimen, and underlying patient conditions.
- *Nursing Implications and Procedure* provides an outline of pretest, intratest, and post-test concerns.
- *Pretest* section addresses the need to:
 - Obtain pertinent clinical, laboratory, dietary, and therapeutic history of the patient, especially as it pertains to comparison of previous test results, preparation for the test, and identification of potentially interfering factors.
 - Understand the interrelationship between various body systems. In this section, the reader is informed of the body systems that may be involved in the study of interest and is referred to body system tables where correlated laboratory and diagnostic studies are alphabetically listed.
 - Explain the requirements and restrictions related to the procedure as well as what to expect; provide the education necessary for the patient to be properly informed.
 - Anticipate and allay patient concerns or anxieties.
 - Provide for patient safety.

- *Intrate*st section can be used in a quality control assessment by the nurse or as a guide to the nurse who may be called on to participate in specimen collection or perform preparatory procedures and gives:
 - Specific directions for specimen collection and test performance.
 - Important information such as patient sensation and expected duration of the procedure.
 - Precautions to be taken by the nurse and patient.
- *Post-test* section provides guidelines regarding:
 - Specific monitoring and therapeutic measures that should be performed after the procedure (e.g., maintaining bed rest, obtaining vital signs to compare with baseline values, signs and symptoms of complications).
 - Specific instructions for the patient and family, such as when to resume usual diet, medications, and activity.
 - General nutritional guidelines related to excess or deficit as well as common food sources for dietary replacement.
 - Indications for interventions from public health representatives or for special counseling related to test outcomes.
 - Indications for follow-up testing that may be required within specific time frames.
 - Related tests for consideration and evaluation, an alphabetical listing of related laboratory and/or diagnostic tests that is intended to provoke a deeper and broader investigation of multiple pieces of information; the tests provide related data that, when combined, can form a more complete picture of health or illness.
 - Reference to the specific body system tables of related laboratory and diagnostic tests that might bear on a patient's situation.

Color and icons have been used to facilitate locating critical information at a glance. On the inside front and back covers is a full color chart describing specific tube tops used for various blood tests and their recommended order of draw.

The nursing process is evident throughout the laboratory and diagnostic monographs. Within each phase of the testing procedure, the nurse has certain roles and responsibilities. These should be evident in reading each monograph.

Information provided in the appendices includes a summary of specimen collection procedures and materials; a summary chart of transfusion reactions, their signs and symptoms, associated laboratory findings, and potential nursing interventions; an introduction to CLIA (Clinical Laboratory Improvement Amendments) with an explanation of the different levels of testing complexity; a summary chart that details suggested approaches to persons at various developmental stages to assist the provider in facilitating cooperation and understanding; a list of some of the herbs and nutraceuticals that have been associated with adverse clinical reactions or have been associated with drug interactions related to the affected body system; and guidelines for Standard and Universal Precautions.

This book is also about teaching. Additional educationally supportive materials are provided for the instructor and student in an *Instructor's Guide*, available on the Instructor's Resource Disk (CD) and posted to DavisPlus (<http://davisplus.fadavis.com>). Organized by nursing curriculum, presentations, and case studies with emphasis on laboratory and diagnostic test-related information and nursing implications have been developed for selected conditions and body systems; new to this edition is the sensory, obstetric, and

nutrition coverage. Open-ended and NCLEX-type multiple-choice questions are provided as well as suggested critical thinking activities. This supplemental material will aid the instructor in integrating laboratory and diagnostic materials in assessment and clinical courses and provide examples of activities to enhance student learning.

Newly developed for this third edition is a robust collection of online material for students and educators posted to the DavisPlus Web site (<http://davisplus.fadavis.com>) including:

- a searchable library of mini-monographs for all the active tests included in the text itself. The mini-monograph gives each test's full name, synonyms/acronyms, specimen type (laboratory tests) or area of application (diagnostic tests), reference ranges or contrast, and results
- an archive of full monographs of retired tests that are referenced by mini-monographs in the text
- interactive drag and drop, quiz show, flash card, and multiple-choice exercises
- a printable file of critical values
- a printable table of monograph template section titles matched to corresponding national patient safety goals
- all the instructor and student material from the Instructor's Resource Disk.

The authors hope that the changes and additions they've made to the book and its CD- and Web-based ancillaries will reward users with an expanded understanding of and appreciation for the place laboratory and diagnostic testing holds in the provision of high-quality nursing care as well as made it easy for instructors to integrate this important content in their curricula.



Preface

Laboratory and diagnostic testing. The words themselves often conjure up cold and impersonal images of needles, specimens lined up in collection containers, and high-tech electronic equipment. But they do not stand alone. They are tied to, bound with, and tell of health or disease in the blood and tissue of a person. Laboratory and diagnostic studies augment the health care provider's assessment of the quality of an individual's physical being. Test results guide the plans and interventions geared toward strengthening life's quality and endurance. Beyond the pounding noise of the MRI, the cold steel of the x-ray table, the sting of the needle, the invasive collection of fluids and tissue, and the probing and inspection is the gathering of evidence that supports the health care provider's ability to discern the course of a disease and the progression of its treatment. Laboratory and diagnostic data must be viewed with thought and compassion, however, as well as with microscopes and machines. We must remember that behind the specimen and test result is the person from whom it came, a person who is someone's son, daughter, mother, father, husband, wife, friend.

This book is written to help health care providers in their understanding and interpretation of laboratory and diagnostic procedures and their outcomes. Just as important, it is dedicated to all health care professionals who experience the wonders in the science of laboratory and diagnostic testing, performed and interpreted in a caring and efficient manner.

Contents

Dedication v

About This Book vii

Preface xiii

Monographs 1

System Tables 1237

APPENDIX A

Patient Preparation and Specimen Collection 1251

APPENDIX B

Potential Nursing Diagnoses Associated with Laboratory
and Diagnostic Testing 1264

APPENDIX C

Guidelines for Age-Specific Communication 1265

APPENDIX D

Transfusion Reactions: Laboratory Findings and Potential
Nursing Interventions 1269

APPENDIX E

Introduction to CLIA 1988 & 1992 1273

APPENDIX F

Effects of Natural Products on Laboratory Values 1274

APPENDIX G

Standard and Universal Precautions 1277

Bibliography 1293

Index 1301

Acetylcholine Receptor Antibody

SYNONYM/ACRONYM: AChR.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay) Less than 0.03 nmol/L.

DESCRIPTION: Normally when impulses travel down a nerve, the nerve ending releases a neurotransmitter called acetylcholine (ACh), which binds to receptor sites in the neuromuscular junction, eventually resulting in muscle contraction. Once the neuromuscular junction has been polarized ACh is rapidly metabolized by the enzyme acetylcholinesterase. When present, acetylcholine receptor (AChR) antibodies block ACh from binding to receptor sites on the muscle membrane. AChR antibodies also destroy AChR sites, interfering with neuromuscular transmission and causing muscle weakness. Antibodies to AChR sites are present in 90% of patients with generalized myasthenia gravis (MG) and in 55% to 70% of patients who either have ocular forms of MG or are in remission. MG is an acquired autoimmune disorder that can occur at any age. It seems to strike women between the ages of 20 and 40 years; men appear to be affected later in life than women. It can affect any voluntary muscle, but muscles that control eye, eyelid, and facial movement and swallowing are most frequently affected. Antibodies may not be detected in the first six to twelve months after the first appearance of symptoms. MG is a common complication associated with thymoma. The relationship between the thymus gland and MG is not completely understood. It is believed that miscommunication in the thymus gland directed at developing

immune cells may trigger the development of autoantibodies responsible for MG. Remission after thymectomy is associated with a progressive decrease in antibody level. Other markers used in the study of MG include muscle AChR-binding antibodies, muscle AChR-blocking antibodies, muscle AChR-modulating antibodies, striational antibodies, thyroglobulin, HLA-B8, and HLA-DR3. These antibodies are often undetectable in the early stages of MG.

INDICATIONS:

- Confirm the presence, but not the severity, of MG
- Detect subclinical MG in the presence of thymoma
- Monitor the effectiveness of immunosuppressive therapy for MG
- Monitor the remission stage of MG

RESULT:

Increased in:

- *(It is believed that miscommunication in the thymus gland directed at developing immune cells may trigger the development of autoantibodies responsible for MG.)*
- Generalized MG
- Thymoma associated with MG

Decreased in:

- Post-thymectomy *(The thymus gland produces the T-lymphocytes responsible for cell-mediated immunity. T-cells also help control B-cell development for the production of antibodies. T-cell response is directed at*

cells in the body that have been infected by bacteria, viruses, parasites, fungi, or protozoans. T-cells also provide immune surveillance for cancerous cells. Removal of the thymus gland is strongly associated with a decrease in AChR antibody levels.)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase AChR levels include penicillamine (long-term use may cause a reversible syndrome that produces clinical, serological, and electrophysiological findings indistinguishable from MG).
- Biological false-positive results may be associated with amyotrophic lateral sclerosis, autoimmune hepatitis, Eaton-Lambert myasthenic syndrome, primary biliary cirrhosis, and encephalomyeloneuropathies associated with carcinoma of the lung.
- Immunosuppressive therapy is the recommended treatment for MG; prior immunosuppressive drug administration may result in negative test results.
- Recent radioactive scans or radiation within 1 wk of the test can interfere with test results when radioimmunoassay is the test method.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify antibodies responsible for

decreased neuromuscular transmission and associated muscle weakness.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, and any prior complications with general anesthesia.
- ▶ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider

(HCP), who will discuss the results with the patient.

- Recognize anxiety related to test results, and be supportive of impaired activity related to lack of neuromuscular control, perceived loss of independence, and fear of shortened life expectancy. Discuss the implications of positive test results on the patient's lifestyle. It is important to note that a diagnosis of MG should be based on positive results from two different diagnostic tests. These tests include AChR antibody assay, edrophonium test, repetitive nerve stimulation, and single-fiber electromyography. Thyrotoxicosis may occur in conjunction with MG; related thyroid testing may be indicated. MG patients may also produce antibodies that demonstrate reactivity in tests like ANA and RF that are not primarily associated with MG. Evaluate test results in relationship to a future general anesthesia, especially regarding therapeutic management of MG with cholinesterase inhibitors. Succinylcholine-sensitive patients may be unable to metabolize the anesthetic quickly, resulting in prolonged or unrecoverable apnea. Provide teaching and information regarding the clinical implications of the test results as appropriate. Educate the patient regarding

access to counseling services. Provide contact information, if desired, for the Myasthenia Gravis Foundation of America (www.myasthenia.org) and Muscular Dystrophy Association (www.mdausa.org).

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. If a diagnosis of MG is made, a computed tomography (CT) scan of the chest should be performed to rule out thymoma. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ANA, antithyroglobulin and antithyroid peroxidase antibodies, CT chest, myoglobin, pseudocholinesterase, RF, TSH, and total T4.
- Refer to the Musculoskeletal System table at the back of the book for related tests by body system.

Acid Phosphatase, Prostatic

SYNONYM/ACRONYM: Prostatic acid phosphatase, *o*-phosphoric monoester phosphohydrolase, AcP.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

A swab with vaginal secretions may be submitted in the appropriate transfer container. Other material such as clothing may be submitted for analysis. Consult the laboratory or emergency services department for the proper specimen collection instructions and containers.

REFERENCE VALUE: (Method: Spectrophotometric)

Conventional & SI Units

Less than 2.5 ng/mL

RESULT:**Increased in:**

- **AcP is released from any damaged cell in which it is stored so diseases of the bone, prostate, and liver that cause cellular destruction demonstrate elevated AcP levels. Conditions that result in abnormal elevations of cells that contain AcP (e.g., leukemia, thrombocytosis) or conditions that result in rapid cellular destruction (sickle cell crisis) also reflect increased levels.**
- Acute myelogenous leukemia
- After prostate surgery or biopsy
- Benign prostatic hypertrophy

- Liver disease
- Lysosomal storage diseases (Gaucher's disease and Niemann-Pick disease). (**AcP is stored in the lysosomes of blood cells and increased levels are present in lysosomal storage diseases.**)
- Metastatic bone cancer
- Paget's disease
- Prostatic cancer
- Prostatic infarct
- Prostatitis
- Sickle cell crisis
- Thrombocytosis

Decreased in: N/A**CRITICAL VALUES:** N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Adrenal Gland Scan

SYNONYM/ACRONYM: Adrenal scintiscan.

AREA OF APPLICATION: Adrenal gland.

CONTRAST: Intravenous radioactive NP-59 (iodomethyl-19-norcholesterol) or metaiodobenzylguanidine (MIBG).

DESCRIPTION: This nuclear medicine study evaluates function of the adrenal glands. The secretory function of the adrenal glands is controlled primarily by the anterior pituitary, which produces adrenocorticotrophic hormone (ACTH). ACTH stimulates the adrenal cortex to produce cortisone and secrete aldosterone. Adrenal imaging is most useful in differentiation of hyperplasia versus adenoma in primary aldosteronism when computed tomography (CT) and magnetic resonance imaging (MRI) findings are equivocal. High concentrations of cholesterol (the precursor in the synthesis of adrenocorticosteroids, including aldosterone) are stored

in the adrenal cortex. This allows the radionuclide, which attaches to the cholesterol, to be used in identifying pathology in the secretory function of the adrenal cortex. The uptake of the radionuclide occurs gradually over time; imaging is performed within 24 to 48 hr of injection of the radionuclide dose and continued daily for 3 to 5 days. Imaging reveals increased uptake, unilateral or bilateral uptake, or absence of uptake in the detection of pathological processes. Following prescanning treatment with corticosteroids, suppression studies can be done to differentiate the presence of tumor from hyperplasia of the glands.

INDICATIONS:

- Aid in the diagnosis of Cushing's syndrome and aldosteronism
- Aid in the diagnosis of gland tissue destruction caused by infection, infarction, neoplasm, or suppression
- Aid in locating adrenergic tumors
- Determine adrenal suppressibility with prescan administration of corticosteroid to diagnose and localize adrenal adenoma, aldosteronomas, androgen excess, and low-renin hypertension
- Differentiate between asymmetric hyperplasia and asymmetry from aldosteronism with dexamethasone suppression test

RESULT:**Normal findings in:**

- No evidence of tumors, infection, infarction, or suppression
- Normal bilateral uptake of radionuclide and secretory function of adrenal cortex
- Normal salivary glands and urinary bladder; vague shape of the liver and spleen sometimes seen

Abnormal findings in:

- Adrenal gland suppression
- Adrenal infarction
- Adrenal tumor
- Hyperplasia
- Infection
- Pheochromocytoma

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.

Factors that may impair clear imaging:

- Retained barium from a previous radiological procedure

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Improper injection of the radionuclide may allow the tracer to seep deep into the muscle tissue, producing erroneous hot spots.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray or radionuclide procedures. Personnel working in the examination area should wear badges to record their radiation exposure level.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure helps assess adrenal gland function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of results of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ All adrenal blood tests should be done before doing this test.
- ▶ Record the date of last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a nuclear medicine department by a

nuclear medicine technologist with support staff, and takes approximately 60 to 120 min each day. Inform the patient the test usually involves a prolonged scanning schedule over a period of days.

- ▶ Administer saturated solution of potassium iodide (SSKI) 24 hr before the study to prevent thyroid uptake of the free radioactive iodine.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of radionuclides or IV fluids.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has removed external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Insert an IV line, and inject the radionuclide IV on day 1; images are taken on days 1, 2, and 3. Imaging is done from the urinary bladder to the base of the skull to scan for a primary tumor. Each image takes 20 min, and total imaging time is 1 to 2 hr per day.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids

for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 24 to 48 hr.

- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Observe the needle site for bleeding, hematoma formation, and inflammation.
- ▶ Instruct the patient in the care and assessment of the injection site.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. Instruct her to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to immediately flush the toilet and to meticulously wash hands with soap and water after each voiding for 48 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 48 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash ungloved hands after the gloves are removed.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Advise the patient that SSKI (120 mg/d) will be administered for 10 days after the injection of the radionuclide. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include ACTH and challenge tests, aldosterone, angiography adrenal, catecholamines, CT abdomen, cortisol and challenge tests,

HVA, MRI abdomen, metanephrines, potassium, renin, sodium, and VMA. Refer to the Endocrine System table at the back of the book for related tests by body system.

Adrenocorticotrophic Hormone (and Challenge Tests)

SYNONYM/ACRONYM: Corticotropin, ACTH.

SPECIMEN: Plasma (2 mL) from lavender-top (EDTA) tube for adrenocorticotrophic hormone (ACTH), and serum (1 mL) from a red-top tube for cortisol. Collect specimens in a prechilled heparinized plastic syringe, and carefully transfer into collection containers by gentle injection to avoid hemolysis. Alternatively, specimens can be collected in prechilled lavender- and red-top tubes. Tiger- and green-top (heparin) tubes are also acceptable for cortisol, but take care to use the same type of collection container for serial measurements. Immediately transport specimen tightly capped and in an ice slurry to the laboratory. The specimens should be immediately processed. Plasma for ACTH analysis should be transferred to a plastic container.

Procedure	Medication Administered, Adult Dosage	Recommended Collection Times
ACTH stimulation, rapid test	1 mg (low-dose protocol) cosyntropin IM	3 cortisol levels: baseline immediately before bolus, 30 min after bolus, and 60 min after bolus
Corticotropin-releasing hormone (CRH) stimulation	IV dose of 1 mg/kg ovine CRH at 9 a.m. or 8 p.m.	8 cortisol and 8 ACTH levels: baseline collected 15 min before injection, 0 min before injection, and then 5, 15, 30, 60, 120, and 180 min after injection
Dexamethasone suppression (overnight)	Oral dose of 1 mg dexamethasone (Decadron) at 11 p.m.	Collect cortisol at 8 a.m. on the morning after the dexamethasone dose
Metyrapone stimulation (overnight)	Oral dose of 30 mg/kg metyrapone with snack at midnight	Collect cortisol and ACTH at 8 a.m. on the morning after the metyrapone dose

IM = intramuscular, IV = intravenous.

REFERENCE VALUE: (Method: Immunoradiometric assay)**ACTH**

Age	Conventional Units	SI Units (Conventional Units × 0.22)
Cord blood	50–570 pg/mL	11–125 pmol/L
Newborn	10–185 pg/mL	2–41 pmol/L
Adult supine specimen collected in morning	9–52 pg/mL	2–11 pmol/L
Women on oral contraceptives	5–29 pg/mL	1–6 pmol/L

ACTH Challenge Tests**ACTH (Cosyntropin)****Stimulated, Rapid Test****Conventional Units****SI Units (Conversion Factor × 27.6)**

Baseline	Cortisol greater than 5 mcg/dL	Greater than 138 nmol/L
30- or 60-min response	Cortisol 18–20 mcg/dL or incremental increase of 7 mcg/dL over baseline value	496–552 nmol/L

Corticotropin-Releasing Hormone Stimulated**Conventional Units****SI Units (Conventional Units × 27.6)**

Cortisol 10 a.m.	359 nmol/L or
13 mcg/dL or 9 p.m.	470 nmol/L
17 mcg/dL	
ACTH 9:30 a.m.	17.6 pmol/L or
80 pg/mL or 8:30 p.m.	6.4 pmol/L
29 pg/mL	

Dexamethasone Suppressed Overnight Test**Conventional Units****SI Units (Conventional Units × 27.6)**

Cortisol less than 3 mcg/dL next day	Less than 83 nmol/L
--------------------------------------	---------------------

Metyrapone Stimulated Overnight Test**Conventional Units****SI Units (Conventional Units × 0.22)**

ACTH greater than 75 pg/mL	Greater than 16.5 pmol/L
Cortisol less than 3 mcg/dL next day	Less than 83 nmol/L

DESCRIPTION: Hypothalamic-releasing factor stimulates the release of adrenocorticotropin hormone (ACTH) from the anterior pituitary gland. ACTH stimulates adrenal cortex secretion of glucocorticoids, androgens, and, to a lesser degree, mineralocorticoids. Cortisol is the major glucocorticoid secreted by the adrenal cortex. ACTH and cortisol test results are evaluated together because normally a change in one causes a change in the other. ACTH secretion is stimulated by insulin, metyrapone, and vasopressin. It is decreased by dexamethasone. Cortisol excess from any source is termed *Cushing syndrome*. Cortisol excess resulting from ACTH excess produced by the pituitary is termed *Cushing disease*. ACTH levels exhibit a diurnal variation, peaking between 6 and 8 a.m. and reaching the lowest point between 6 and 11 p.m. Evening levels are generally one-half to two-thirds lower than morning levels. Cortisol levels also vary diurnally, with the lowest values occurring during the morning and peak levels occurring in the evening.

INDICATIONS:

- Determine adequacy of replacement therapy in congenital adrenal hyperplasia
- Determine adrenocortical dysfunction
- Differentiate between increased ACTH release with decreased cortisol levels and decreased ACTH release with increased cortisol levels

RESULT:

ACTH Result:

Because ACTH and cortisol secretion exhibit diurnal variation with

values being highest in the morning, a lack of change in values from morning to evening is clinically significant. Decreased concentrations of hormones secreted by the pituitary gland and its target organs are observed in hypopituitarism. In primary adrenal insufficiency (Addison's disease) due to adrenal gland destruction by tumor, infectious process, or immune reaction, ACTH levels are elevated while cortisol levels are decreased. Both ACTH and cortisol levels are decreased in secondary adrenal insufficiency (i.e., secondary to pituitary insufficiency). Excess ACTH can be produced ectopically by various lung cancers such as oat cell carcinoma and large-cell carcinoma of the lung and by benign bronchial carcinoid tumor.

Challenge Tests and Results:

The ACTH (cosyntropin) stimulated rapid test directly evaluates adrenal gland function and indirectly evaluates pituitary gland and hypothalamus function. Cosyntropin is a synthetic form of ACTH. A baseline cortisol level is collected before the injection of cosyntropin. Specimens are subsequently collected at 30- and 60-min intervals. If the adrenal glands function normally, cortisol levels rise significantly after administration of cosyntropin.

The CRH stimulation test works as well as the dexamethasone suppression test (DST) in distinguishing Cushing's disease from conditions in which ACTH is secreted ectopically (e.g., tumors not located in the pituitary gland that secrete ACTH). Patients with pituitary tumors tend to respond to CRH stimulation, whereas those with ectopic tumors do not. Patients with adrenal insufficiency demonstrate one of three

patterns depending on the underlying cause:

- **Primary adrenal insufficiency**—high baseline ACTH (in response to intravenous [IV] ACTH) and low cortisol levels pre- and post-IV ACTH.
- **Secondary adrenal insufficiency (pituitary)**—low baseline ACTH that does not respond to ACTH stimulation. Cortisol levels do not increase after stimulation.
- **Tertiary adrenal insufficiency (hypothalamic)**—low baseline ACTH with an exaggerated and prolonged response to stimulation. Cortisol levels usually do not reach 20 mcg/dL.

The DST is useful in differentiating the causes of increased cortisol levels. Dexamethasone is a synthetic glucocorticoid that is 64 times more potent than cortisol. It works by negative feedback. It suppresses the release of ACTH in patients with a normal hypothalamus. A cortisol level less than 3.0 mcg/dL usually excludes Cushing's syndrome. With the DST, a baseline morning cortisol level is collected, and the patient is given a 1-mg dose of dexamethasone at bedtime. A second specimen is collected the following morning. If cortisol levels have not been suppressed, adrenal adenoma is suspected. The DST also produces abnormal results in the presence of certain psychiatric illnesses (e.g., endogenous depression).

The metyrapone stimulation test is used to distinguish corticotropin-dependent causes (pituitary Cushing's disease and ectopic Cushing's disease) from corticotropin-independent causes (e.g., carcinoma of the lung or thyroid) of increased cortisol levels. Metyrapone inhibits the conversion of 11-deoxycortisol to cortisol. Cortisol levels should decrease to less than 3 mcg/dL if normal pituitary stimu-

lation by ACTH occurs after an oral dose of metyrapone. Specimen collection and administration of the medication are performed as with the overnight dexamethasone test.

Increased in:

- Overproduction of ACTH can occur as either a direct result of disease (e.g., primary or ectopic tumor that secretes ACTH), stimulation by physical or emotional stress, or an indirect response to abnormalities in the complex feedback mechanisms involving the pituitary gland, hypothalamus, or adrenal glands.

ACTH Increased in:

- Addison's disease (**primary adrenocortical hypofunction**)
- Carcinoid syndrome
- Congenital adrenal hyperplasia
- Cushing's disease (**pituitary-dependent adrenal hyperplasia**)
- Depression
- Ectopic ACTH-producing tumors
- Menstruation
- Nelson's syndrome (**ACTH-producing pituitary tumors**)
- Non-insulin-dependent diabetes
- Pregnancy
- Sepsis
- Septic shock

Decreased in:

- **Secondary adrenal insufficiency due to hypopituitarism (inadequate production by the pituitary) can result in decreased levels of ACTH.**

ACTH Decreased in:




- Adrenal adenoma
- Adrenal cancer
- Cushing syndrome
- **Conditions that result in overproduction or availability**

of high levels of cortisol can result in decreased levels of ACTH.

- Exogenous steroid therapy

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase ACTH levels include estrogens, insulin, metoclopramide, metyrapone, mifepristone (RU 486), and vasopressin.
- Drugs that may decrease ACTH levels include corticosteroids (e.g., dexamethasone) and pravastatin.
- Test results are affected by the time the test is done because ACTH levels vary diurnally, with the highest values occurring between 6 and 8 a.m. and the lowest values occurring at night. Samples should be collected at the same time of day, between 6 and 8 a.m.
- Excessive physical activity can produce elevated levels.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when immunoradiometric assay is the test method.
-  The metyrapone stimulation test is contraindicated in patients with suspected adrenal insufficiency.
-  Metyrapone may cause gastrointestinal distress and/or confusion. Administer oral dose of metyrapone with milk and snack.
-  Rapid clearance of metyrapone, resulting in falsely increased cortisol levels, may occur if the patient is taking drugs that enhance steroid metabolism (e.g., phenytoin, rifampin, phenobarbital, mitotane, and corticosteroids). The primary care practitioner should be consulted prior to a metyrapone stimulation test regarding a decision to withhold these medications.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess for pituitary hormone deficiency.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Weigh patient and report weight to pharmacy for dosing of metyrapone (30 mg/kg body weight).
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, especially drugs that enhance steroid metabolism, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. When ACTH hypersecretion is suspected, a second sample may be requested between 6 and 8 p.m. to determine if changes are the result of diurnal variation in ACTH levels. Inform the patient that more than one sample may be necessary to ensure accurate results and samples are obtained at specific times to determine high and low levels of ACTH. Inform the patient that each specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ Drugs that enhance steroid metabolism may be withheld by medical direction prior to metyrapone stimulation testing.

- ▶ Instruct the patient to refrain from strenuous exercise for 12 hr before the test and to remain in bed or at rest for 1 hr immediately before the test. Avoid smoking and alcohol use.
- ▶ Prepare an ice slurry in a cup or plastic bag to have on hand for immediate transport of the specimen to the laboratory.

INTRATEST:

- ▶ Ensure that strenuous exercise was avoided for 12 hr before the test and that 1 hr of bed rest was taken immediately before the test. Samples should be collected between 6 and 8 a.m.
- ▶ Have emergency equipment readily available in case of adverse reaction to metyrapone.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a prechilled plastic heparinized syringe or in prechilled collection containers as listed under the "Specimen" subheading.
- ▶ Adverse reactions to metyrapone include nausea and vomiting (N/V), abdominal pain, headache, dizziness, sedation, allergic rash, decreased WBC count, and bone marrow depression. Signs and symptoms of overdose or acute adrenocortical insufficiency include cardiac arrhythmias, hypotension, dehydration, anxiety, confusion, weakness, impairment of consciousness, N/V, epigastric pain, diarrhea, hyponatremia, and hyperkalemia.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation

and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume normal activity as directed by the HCP.
- ▶ Recognize anxiety related to test results, and offer support. Provide contact information, if desired, for the Cushing's Support and Research Foundation (www.csrff.net).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. If a diagnosis of Cushing's disease is made, pituitary computed tomography (CT) or magnetic resonance imaging (MRI) may be indicated prior to surgery. If a diagnosis of ectopic corticotropin syndrome is made, abdominal CT or MRI may be indicated prior to surgery. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include cortisol and challenge tests, CT abdomen, CT pituitary, MRI abdomen, MRI pituitary, TSH, and thyroxine.
- ▶ See the Endocrine System table at the back of the book for related tests by body system.

Alanine Aminotransferase

A

SYNONYM/ACRONYM: Serum glutamic pyruvic transaminase (SGPT), ALT.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in a green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional & SI Units
Newborn–1 yr	13–45 units/L
2 yr–adult	
Male	10–40 units/L
Female	7–35 units/L

DESCRIPTION: Alanine aminotransferase (ALT), formerly known as serum glutamic pyruvic transaminase (SGPT), is an enzyme produced by the liver. The highest concentration of ALT is found in liver cells, moderate amounts are found in kidney cells, and smaller amounts are found in heart, pancreas, spleen, skeletal muscle, and red blood cells. When liver damage occurs, serum levels of ALT rise to 50 times normal, making this a useful test in evaluating liver injury.

INDICATIONS:

- Compare serially with aspartate aminotransferase (AST) levels to track the course of liver disease
- Monitor liver damage resulting from hepatotoxic drugs
- Monitor response to treatment of liver disease, with tissue repair indicated by gradually declining levels

RESULT:

Increased in:

- **ALT is released from any damaged cell in which it is stored so conditions that affect the liver, kidneys, heart, or skeletal muscle and cause cellular destruction demonstrate elevated ALT levels.**
- Acquired immune deficiency syndrome (related to Hepatitis B coinfection)
- Acute pancreatitis
- Biliary tract obstruction
- Burns (severe)
- Chronic alcohol abuse
- Cirrhosis
- Fatty liver
- Hepatic carcinoma
- Hepatitis
- Infectious mononucleosis
- Muscle injury from intramuscular injections, trauma, infection, and seizures (recent)
- Muscular dystrophy
- Myocardial infarction
- Myositis
- Pre-eclampsia
- Shock (severe)

Decreased in:

- Pyridoxal phosphate deficiency (**Pyridoxal phosphate is a required coenzyme in the amino transfer reactions**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase ALT levels by causing cholestasis include anabolic steroids, dapson, estrogens, ethionamide, icterogenin, mepazine, methandriol, oral contraceptives, oxymetholone, propoxyphene, sulfonyleureas, and zidovudine.
- Drugs that may increase ALT levels by causing hepatocellular damage include acetaminophen (toxic), acetylsalicylic acid, amiodarone, anticonvulsants, asparaginase, carbutamide, cephalosporins, chloramphenicol, clofibrate, cytarabine, danazol, dinitrophenol, enflurane, erythromycin, ethambutol, ethionamide, ethotoin, florantyrone, foscarnet, gentamicin, gold salts, halothane, ibufenac, indomethacin, interleukin-2, isoniazid, lincomycin, low-molecular-weight heparin, metahexamide, metaxalone, methoxsalen, methyl dopa, methylthiouracil, naproxen, nitrofurans, oral contraceptives, probenecid, procainamide, and tetracyclines.
- Drugs that may decrease ALT levels include cyclosporine, interferon, and ursodiol.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess liver function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle, and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding and hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, or activity, as directed by the HCP.
- ▶ *Nutritional considerations:* Increased ALT levels may be associated with liver disease. Dietary recommendations

may be indicated and vary depending on the severity of the condition. A low-protein diet may be in order if the patient's liver has lost the ability to process the end products of protein metabolism. A diet of soft foods may be required if esophageal varices have developed. Ammonia levels may be used to determine whether protein should be added to or reduced from the diet. Patients should be encouraged to eat simple carbohydrates and emulsified fats (as in homogenized milk or eggs), as opposed to complex carbohydrates (e.g., starch, fiber, and glycogen [animal carbohydrates]) and complex fats, which would require additional bile to emulsify them so that they can be used. The cirrhotic patient should be carefully observed for the development of ascites, in which case fluid and electrolyte balance requires strict attention.

- Reinforce information given by the patient's HCP regarding further testing,

treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include acetaminophen, ammonia, AST, bilirubin, biopsy liver, cholangiography percutaneous transhepatic, electrolytes, GGT, hepatitis antigens and antibodies, LDH, liver and spleen scan, and US liver.
- See the Hepatobiliary System table at the back of the book for related tests by body system.

A

Albumin and Albumin/Globulin Ratio

SYNONYM/ACRONYM: Alb, A/G ratio.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in a green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry) Normally the albumin/globulin (A/G) ratio is greater than 1.

Age	Conventional Units	SI Units (Conventional Units × 10)
Newborn–11 mo	2.9–5.5 g/dL	29–55 g/L
1–40 yr	3.7–5.1 g/dL	37–51 g/L
41–60 yr	3.4–4.8 g/dL	34–48 g/L
61–90 yr	3.2–4.6 g/dL	32–46 g/L
Greater than 90 yr	2.9–4.5 g/dL	29–45 g/L

DESCRIPTION: Most of the body's total protein is a combination of albumin and globulins. Albumin, the protein present in the highest concentrations, is the main transport protein in the body. Albumin is synthesized in the liver. Low levels of albumin may be the result of either inadequate intake, inadequate production, or excessive loss. Albumin levels are more useful as an indicator of chronic deficiency than of short-term deficiency.

Albumin levels are affected by posture. Results from specimens collected in an upright posture are higher than results from specimens collected in a supine position.

The albumin/globulin (A/G) ratio is useful in the evaluation of liver and kidney disease. The ratio is calculated using the following formula:

$$\text{albumin}/(\text{total protein} - \text{albumin})$$

where globulin is the difference between the total protein value and the albumin value. For example, with a total protein of 7 g/dL and albumin of 4 g/dL, the A/G ratio is calculated as $4/(7 - 4)$ or $4/3 = 1.33$. A reversal in the ratio, where globulin exceeds albumin (i.e., ratio less than 1.0), is clinically significant.

INDICATIONS:

- Assess nutritional status of hospitalized patients, especially geriatric patients
- Evaluate chronic illness
- Evaluate liver disease

RESULT:

Increased in:

- *Any condition that results in a decrease of plasma water*

(e.g., dehydration); look for increase in hemoglobin and hematocrit. (Decreases in the volume of intravascular liquid automatically result in concentration of the components present in the remaining liquid as reflected by an elevated albumin level.)

- Hyperinfusion of albumin.

Decreased in:

- *Insufficient intake:*

Malabsorption

Malnutrition

- *Decreased synthesis by the liver:*

Acute and chronic liver disease

(e.g., alcoholism, cirrhosis, hepatitis)

Genetic analbuminemia

- *Inflammation and chronic diseases result in production of acute phase reactant and other globulin proteins; the increase in globulins causes a corresponding decrease in albumin:*

Amyloidosis

Bacterial infections

Monoclonal gammopathies (e.g., multiple myeloma, Waldenström's macroglobulinemia)

Neoplasm

Parasitic infestations

Peptic ulcer

Prolonged immobilization

Rheumatic diseases

Severe skin disease

- Increased loss over body surface:
 - Burns*
 - Enteropathies related to sensitivity to ingested substances (e.g., gluten sensitivity, Crohn's disease, ulcerative colitis)*
 - Fistula (gastrointestinal or lymphatic)*
 - Hemorrhage*
 - Kidney disease*
 - Rapid hydration or overhydration*
 - Repeated thoracentesis or paracentesis*
 - Trauma and crush injuries*

Increased catabolism:

- Fever
- Cushing's disease
- Pre-eclampsia
- Thyroid dysfunction

Increased blood volume (hypervolemia):

- Congestive heart failure
- Pregnancy

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase albumin levels include cyclosporine, enalapril, and furosemide.
- Drugs that may decrease albumin levels include acetaminophen (poisoning), asparaginase, dapsone, dextran, estrogens, ibuprofen, interleukin-2, methotrexate, methyl dopa, niacin, nitrofurantoin, oral contraceptives, phenytoin, trazodone, ursodiol, and valproic acid.
- Availability of administered drugs is affected by variations in albumin levels.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used as a general indicator of nutritional status, hydration, and chronic disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal, genitourinary, and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations:* Dietary recommendations may be indicated and will vary depending on the severity of the condition. Ammonia levels may

be used to determine whether protein should be added to or reduced from the diet.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, ALP, ammonia, anti-smooth muscle antibody, AST, bilirubin, biopsy liver, complete blood count hematocrit, complete blood count hemoglobin, CT biliary tract and liver, GGT, hepatitis antibodies and antigens, KUB studies, laparoscopy abdominal, liver scan, MRI abdomen, osmolality, potassium, prealbumin, protein total and fractions, radiofrequency ablation liver, sodium, and US liver.
- ▶ See the Gastrointestinal, Genitourinary, Hepatobiliary, and System tables at the back of the book for related tests by body system.

Aldolase

SYNONYM/ACRONYM: ALD.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional & SI Units
Newborn–2 yr	3.4–11.8 units/L
25 m–16 yr	1.2–8.8 units/L
Adult	Less than 7.4 units/L

RESULT:

Increased in:

- **ALD is released from any damaged cell in which it is stored so diseases of the muscle, heart, and liver that cause cellular destruction**

demonstrate elevated ALD levels.

- Carcinoma (lung, breast, and genitourinary tract, and metastasis to liver)
- Central nervous system tumors
- Dermatomyositis
- Duchenne's muscular dystrophy
- Hemolytic anemias
- Hepatitis (acute viral or toxic)
- Leukemia (granulocytic and megaloblastic)
- Limb girdle muscular dystrophy

- Myocardial infarction
- Pancreatitis (acute)
- Polymyositis
- Psychoses and schizophrenia (acute)
- Severe crush injuries
- Tetanus
- Trichinosis (*related to myositis*)

Decreased in:

- Hereditary fructose intolerance (*hereditary deficiency of the aldolase B enzyme*)
- *Late stages of muscle wasting diseases where muscle mass has significantly diminished*

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Aldosterone

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) or lavender-top (EDTA) tube is also acceptable.

REFERENCE VALUE: (Method: Radioimmunoassay)

Age	Conventional Units	SI Units (Conventional Units × 0.0277)
Cord blood	40–200 ng/dL	1.11–5.54 nmol/L
3 d–1 wk	7–184 ng/dL	0.19–5.10 nmol/L
1 mo–1 yr	5–90 ng/dL	0.14–2.49 nmol/L
13–23 mo	7–54 ng/dL	0.19–1.50 nmol/L
2–10 yr		
<i>Supine</i>	3–35 ng/dL	0.08–0.97 nmol/L
<i>Upright</i>	5–80 ng/dL	0.14–2.22 nmol/L
11–15 yr		
<i>Supine</i>	2–22 ng/dL	0.06–0.61 nmol/L
<i>Upright</i>	4–48 ng/dL	0.11–1.33 nmol/L
Adult		
<i>Supine</i>	3–16 ng/dL	0.08–0.44 nmol/L
<i>Upright</i>	7–30 ng/dL	0.19–0.83 nmol/L

These values reflect a normal-sodium diet. Values for a low-sodium diet are three to five times higher.

DESCRIPTION: Aldosterone is a mineralocorticoid secreted by the zona glomerulosa of the adrenal cortex in response to

decreased serum sodium, decreased blood volume, and increased serum potassium. Aldosterone increases sodium

reabsorption in the renal tubules, resulting in potassium excretion and increased water retention, blood volume, and blood pressure. A variety of factors influence serum aldosterone levels, including sodium intake, certain medications, and activity. This test is of little diagnostic value unless plasma renin activity is measured simultaneously (see monograph titled “Renin”). Patients with serum potassium less than 3.6 mEq/L and 24-hour urine potassium greater than 40 mEq/L fit the general criteria to test for aldosteronism. Renin is low in primary aldosteronism and high in secondary aldosteronism. A ratio of plasma aldosterone to plasma renin activity greater than 50 is significant. Ratios greater than 20 obtained after unchallenged screening may indicate the need for further evaluation with a sodium-loading protocol. A captopril protocol can be substituted for patients who may not tolerate the sodium-loading protocol.

INDICATIONS:

- Evaluate hypertension of unknown cause, especially with hypokalemia not induced by diuretics
- Investigate suspected hyperaldosteronism, as indicated by elevated levels
- Investigate suspected hypoaldosteronism, as indicated by decreased levels

RESULT:

Increased with Decreased Renin Levels

Primary hyperaldosteronism (overproduction due to abnormal adrenal gland function):

- Adenomas (Conn's syndrome)

- Bilateral hyperplasia of the aldosterone-secreting zona glomerulosa cells

Increased with Increased Renin Levels

Secondary hyperaldosteronism (some conditions that result in increased renin levels will stimulate aldosterone secretion):

- Bartter's syndrome
- Cardiac failure
- Chronic obstructive pulmonary disease
- Cirrhosis with ascites formation
- Diuretic abuse (**directly stimulates aldosterone secretion**)
- Hypovolemia **secondary to hemorrhage and transudation**
- Laxative abuse (**directly stimulates aldosterone secretion**)
- Nephrotic syndrome
- Starvation (after 10 days)
- Thermal stress
- Toxemia of pregnancy

Decreased in:

Without hypertension:

- Addison's disease (**the adrenal cortex is not functioning, therefore aldosterone is not secreted**)
- Hypoaldosteronism **secondary to renin deficiency**
- Isolated aldosterone deficiency

With hypertension:

- Acute alcohol intoxication (**toxic effects of alcohol can affect adrenal gland function and therefore secretion of aldosterone**)
- Diabetes (**impaired conversion of prerenin to renin by damaged kidneys results in decreased aldosterone**)
- Excess secretion of deoxycorticosterone (**cortisol suppresses production of ACTH, which in turn affects aldosterone secretion**)

- Turner's syndrome (25% of cases) (**congenital adrenal hyperplasia can result in underproduction of aldosterone and overproduction of androgens**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase aldosterone levels include amiloride, ammonium chloride, angiotensin, angiotensin II, dobutamine, dopamine, endralazine, fenoldopam, hydralazine, hydrochlorothiazide, laxatives (abuse), metoclopramide, nifedipine, opiates, potassium, spironolactone, and zacopride.
- Drugs that may decrease aldosterone levels include atenolol, captopril, carvedilol, cilazapril, enalapril, fadrozole, glycyrrhiza (licorice), ibopamine, indomethacin, lisinopril, nicardipine, NSAIDs, perindopril, ranitidine, saline, sinorphan, and verapamil. Prolonged heparin therapy also decreases aldosterone levels.
- Upright body posture, stress, strenuous exercise, and late pregnancy can lead to increased levels.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.
- Diet can significantly affect results. A low-sodium diet can increase serum aldosterone, whereas a high-sodium diet can decrease levels. Decreased serum sodium and elevated serum potassium increase aldosterone secretion. Elevated serum sodium and decreased serum potassium suppress aldosterone secretion.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers

before providing care, treatment, or services.

- ♦ Inform the patient that the test is used to evaluate hypertension and possible hyperaldosteronism.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of known or suspected fluid or electrolyte imbalance, hypertension, renal function, or stage of pregnancy. Note the amount of sodium ingested in the diet over the past 2 wk.
- ♦ Obtain a history of the patient's endocrine and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Inform the patient that multiple specimens may be required. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ Inform the patient that the required position, supine/lying down or upright/sitting up, must be maintained for 2 hr before specimen collection. Some health care providers (HCP) may also order administration of furosemide (40–80 mg) upon arising.
- ♦ The patient should be on a normal-sodium diet (1 to 2 g of sodium per day) for 2 to 4 wk before the test. Protocols may vary from facility to facility.
- ♦ Under medical direction, the patient should avoid diuretics, antihypertensive drugs and herbals, and cyclic progestogens and estrogens for 2 to 4 wk before the test.

INTRATEST:

- ♦ Ensure that the patient has complied with dietary, medication, and pretesting preparations regarding activity.

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, time of collection, patient position (upright or supine), and exact source of specimen (peripheral versus arterial). Perform a venipuncture after the patient has been in the upright (sitting or standing) position for 2 hr. If a supine specimen is requested on an inpatient, the specimen should be collected early in the morning before rising.
- ▶ Remove the needle, and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen on ice to the laboratory for processing and analysis.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, medication, and activity as directed by the HCP.
- ▶ Instruct the patient to notify the HCP of any signs and symptoms of dehydration or fluid overload related to elevated aldosterone levels or compromised sodium regulatory mechanisms.
- ▶ **Nutritional considerations:** Aldosterone levels are involved in the regulation of body fluid volume. Educate patients about the importance of proper water balance. Although there is no recommended dietary allowance (RDA) for water, adults need 1 mL/kcal per day. Infants need more water because their basal metabolic heat production is much higher than in adults. Tap water may also contain other nutrients. Water-softening systems replace minerals (e.g., calcium, magnesium, iron) with sodium, so caution should be used if a low-sodium diet is prescribed.

- ▶ **Nutritional considerations:** Because aldosterone levels have an effect on sodium levels, some consideration may be given to dietary adjustment if sodium allowances need to be regulated. Educate patients with low sodium levels that the major source of dietary sodium is table salt. Many foods, such as milk and other dairy products, are also good sources of dietary sodium. Most other dietary sodium is available through consumption of processed foods. Patients who need to follow low-sodium diets should avoid beverages such as colas, ginger ale, Gatorade, lemon-lime sodas, and root beer. Many over-the-counter medications, including antacids, laxatives, analgesics, sedatives, and antitussives, contain significant amounts of sodium. The best advice is to emphasize the importance of reading all food, beverage, and medicine labels. In 1989, the Subcommittee on the 10th Edition of the RDAs established 500 mg as the recommended minimum limit for dietary intake of sodium. There are no RDAs established for potassium, but the estimated minimum intake for adults is 200 mEq/d. Potassium is present in all plant and animal cells, making dietary replacement simple. An HCP or nutritionist should be consulted before considering the use of salt substitutes.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include adrenal gland scan, biopsy kidney, BUN, catecholamines, cortisol, creatinine, glucose, magnesium, osmolality, potassium, protein urine, renin, sodium, and UA.
- ▶ See the Endocrine and Genitourinary System tables at the back of the book for related tests by body system.

Alkaline Phosphatase and Isoenzymes

SYNONYM/ACRONYM: Alk Phos, ALP and fractionation, heat-stable ALP.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in a green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry for total alkaline phosphatase, inhibition/electrophoresis for fractionation)

Total ALP	Conventional & SI Units	Bone Fraction	Liver Fraction
1–5 yr			
<i>Male</i>	56–350 units/L	39–308 units/L	Less than 8–101 units/L
<i>Female</i>	73–378 units/L	56–300 units/L	Less than 8–53 units/L
6–7 yr			
<i>Male</i>	70–364 units/L	50–319 units/L	Less than 8–76 units/L
<i>Female</i>	73–378 units/L	56–300 units/L	Less than 8–53 units/L
8 yr			
<i>Male</i>	70–364 units/L	50–258 units/L	Less than 8–62 units/L
<i>Female</i>	98–448 units/L	78–353 units/L	Less than 8–62 units/L
9–12 yr			
<i>Male</i>	112–476 units/L	78–339 units/L	Less than 8–81 units/L
<i>Female</i>	98–448 units/L	78–353 units/L	Less than 8–62 units/L
13 yr			
<i>Male</i>	112–476 units/L	78–389 units/L	Less than 8–48 units/L
<i>Female</i>	56–350 units/L	28–252 units/L	Less than 8–50 units/L
14 yr			
<i>Male</i>	112–476 units/L	78–389 units/L	Less than 8–48 units/L
<i>Female</i>	56–266 units/L	31–190 units/L	Less than 8–48 units/L
15 yr			
<i>Male</i>	70–378 units/L	48–311 units/L	Less than 8–39 units/L
<i>Female</i>	42–168 units/L	20–115 units/L	Less than 8–53 units/L
16 yr			
<i>Male</i>	70–378 units/L	48–311 units/L	Less than 8–39 units/L
<i>Female</i>	28–126 units/L	14–87 units/L	Less than 8–50 units/L
17 yr			
<i>Male</i>	56–238 units/L	34–190 units/L	Less than 8–39 units/L
<i>Female</i>	28–126 units/L	17–84 units/L	Less than 8–53 units/L
18 yr			
<i>Male</i>	56–182 units/L	34–146 units/L	Less than 8–39 units/L
<i>Female</i>	28–126 units/L	17–84 units/L	Less than 8–53 units/L
19 yr			
<i>Male</i>	42–154 units/L	25–123 units/L	Less than 8–39 units/L
<i>Female</i>	28–126 units/L	17–84 units/L	Less than 8–53 units/L
20 yr			
<i>Male</i>	45–138 units/L	25–73 units/L	Less than 8–48 units/L
<i>Female</i>	33–118 units/L	17–56 units/L	Less than 8–50 units/L
Adult			
<i>Male</i>	35–142 units/L	11–73 units/L	0–93 units/L
<i>Female</i>	25–125 units/L	11–73 units/L	0–93 units/L

DESCRIPTION: Alkaline phosphatase (ALP) is an enzyme found in the liver, in Kupffer cells lining the biliary tract, and in bones, intestines, and placenta. Additional sources of ALP include the proximal tubules of the kidneys, pulmonary alveolar cells, germ cells, vascular bed, lactating mammary glands, and granulocytes of circulating blood. ALP is referred to as alkaline because it functions optimally at a pH of 9.0. This test is most useful for determining the presence of liver or bone disease.

Isoelectric focusing methods can identify 12 isoenzymes of ALP. Certain cancers produce small amounts of distinctive Regan and Nagao ALP isoenzymes. Elevations in three main ALP isoenzymes, however, are of clinical significance: ALP₁ of liver origin, ALP₂ of bone origin, and ALP₃ of intestinal origin (normally only present in individuals with blood types O and B). ALP levels vary by age and gender. Values in children are higher than in adults because of the level of bone growth and development. An immunoassay method is available for measuring bone-specific ALP as an indicator of increased bone turnover and estrogen deficiency in postmenopausal women.

INDICATIONS:

- Evaluate signs and symptoms of various disorders associated with elevated ALP levels, such as biliary obstruction, hepatobiliary disease, and bone disease, including malignant processes
- Differentiate obstructive hepatobiliary tract disorders from hepatocellular disease; greater elevations of ALP are seen in the former
- Determine effects of renal disease on bone metabolism
- Determine bone growth or destruction in children with abnormal growth patterns

RESULT:

Increased in:

- ***Alkaline phosphatase is released from any damaged cell in which it is stored so diseases of the bone, biliary tract, and liver that cause cellular destruction demonstrate elevated alkaline phosphatase levels.***
- Liver disease:
 - Biliary atresia
 - Biliary obstruction (acute cholecystitis, cholelithiasis, intrahepatic cholestasis of pregnancy, primary biliary cirrhosis)
 - Cancer
 - Chronic active hepatitis
 - Cirrhosis
 - Diabetes (diabetic hepatic lipidosis)
 - Extrahepatic duct obstruction
 - Granulomatous or infiltrative liver diseases (sarcoidosis, amyloidosis, TB)
 - Infectious mononucleosis
 - Intrahepatic biliary hypoplasia
 - Toxic hepatitis
 - Viral hepatitis
- Bone disease:
 - Healing fractures
 - Metabolic bone diseases (rickets, osteomalacia)
 - Metastatic tumors in bone
 - Osteogenic sarcoma
 - Osteoporosis
 - Paget's disease (osteitis deformans)
- Other conditions:
 - Advanced pregnancy (***from placenta and new bone growth; marked decline is seen with placental insufficiency and imminent fetal demise***)
 - Cancer of the breast, colon, gallbladder, lung, or pancreas
 - Congestive heart failure
 - Familial hyperphosphatemia
 - Hyperparathyroidism
 - Perforated bowel
 - Pneumonia

Pulmonary and myocardial infarctions
 Pulmonary embolism
 Ulcerative colitis

Decreased in:

- Anemia (severe)
- Celiac disease
- Folic acid deficiency
- HIV-1 infection
- Hypervitaminosis D
- Hypophosphatasia (**congenital and rare; there is insufficient phosphorus available to make ALP**)
- Hypothyroidism (characteristic in infantile and juvenile cases)
- Nutritional deficiency of zinc or magnesium
- Pernicious anemia
- Scurvy
- Vitamin C deficiency
- Whipple's disease
- Zollinger-Ellison syndrome

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase ALP levels by causing cholestasis include anabolic steroids, erythromycin, estrogens, ethionamide, gold salts, imipramine, interleukin-2, mercaptopurine, nitrofurans, oral contraceptives, penicillins, phenothiazines, propoxyphene, sulfonamides, and tolbutamide.
- Drugs that may increase ALP levels by causing hepatocellular damage include acetaminophen (toxic), amiodarone, anticonvulsants, asparaginase, bromocriptine, captopril, cephalosporins, chloramphenicol, enflurane, ethionamide, foscarnet, gentamicin, indomethacin, lincomycin, methyl dopa, naproxen, nitrofurans, probenecid, procainamide, progesterone, ranitidine, and verapamil.
- Drugs that may cause an overall decrease in ALP levels include

alendrolate, azathioprine, clofibrate, estrogens with estrogen replacement therapy, and theophylline.

- Hemolyzed specimens may cause falsely elevated results.
- Elevations of ALP may occur if the patient is nonfasting, usually 2 to 4 hr after a fatty meal, and especially if the patient is a Lewis-positive secretor of blood group B or O.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess liver function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the

patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding and hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Increased ALP levels may be associated with liver disease. Dietary recommendations may be indicated and vary depending on the severity of the condition. A low-protein diet may be in order if the patient's liver has lost the ability to process the end products of protein metabolism. A diet of soft foods may be required if esophageal varices have developed. Ammonia levels may be used to determine whether protein should be added to or reduced from the diet. Patients should be encouraged to eat simple carbohydrates and emulsified fats (as in homogenized milk or eggs), as opposed to complex carbohydrates (e.g., starch, fiber, and glycogen [animal carbohydrates]) and

complex fats, which require additional bile to emulsify them so that they can be used. The cirrhotic patient should be carefully observed for the development of ascites, in which case fluid and electrolyte balance requires strict attention.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include acetaminophen, ALT, albumin, ammonia, anti-DNA antibodies, AMA/ASMA, ANA, α_1 -antitrypsin, α_1 -antitrypsin phenotyping, AST, bilirubin, biopsy bone, biopsy liver, bone scan, BMD, calcium, ceruloplasmin, collagen cross-linked telopeptides, C3 and C4, complements, copper, ERCP, GGT, hepatitis antigens and antibodies, hepatobiliary scan, KUB studies, magnesium, MRI abdomen, osteocalcin, PTH, phosphorus, potassium, protein, protein electrophoresis, PT/INR, salicylate, sodium, US liver, vitamin D, and zinc.
- ▶ See the Hepatobiliary and Musculoskeletal System tables at the back of the book for related tests by body system.

Allergen-Specific Immunoglobulin E

SYNONYM/ACRONYM: Allergen profile, radioallergosorbent test (RAST).

SPECIMEN: Serum (2 mL per group of six allergens, 0.5 mL for each additional individual allergen) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

RAST Scoring Method**Alternate Scoring Method (ASM): Increasing Levels of Allergy Sensitivity**

<i>Specific IgE Antibody Level</i>	<i>kInternational Units/L</i>	<i>ASM Class</i>	<i>ASM % Reference</i>
Absent or undetectable	Less than 0.35	0	Less than 70
Low	0.35–0.70	1	70–109
Moderate	0.71–3.50	2	110–219
High	3.51–17.50	3	220–599
Very high	Greater than 17.50	4	600–1999
		5	2000–5999
		6	Greater than 5999

DESCRIPTION: Allergen-specific immunoglobulin E (IgE) or a radioallergosorbent test (RAST) is generally requested for groups of allergens commonly known to incite an allergic response in the affected individual. The test is based on the use of a radio-labeled anti-IgE reagent to detect IgE in the patient's serum, produced in response to specific allergens. The panels include allergens such as animal dander, antibiotics, dust, foods, grasses, insects, trees, mites, molds, venom, and weeds. Allergen testing is useful for evaluating the cause of hay fever, extrinsic asthma, atopic eczema, respiratory allergies, and potentially fatal reactions to insect venom, penicillin, and other drugs or chemicals. RAST is an alternative to skin test anergy and provocation procedures, which can be inconvenient, painful, and potentially hazardous to patients.

INDICATIONS:

- Evaluate patients who refuse to submit to skin testing or who have generalized dermatitis or other dermatopathic conditions

- Monitor response to desensitization procedures
- Test for allergens when skin testing is inappropriate, such as in infants
- Test for allergens when there is a known history of allergic reaction to skin testing
- Test for specific allergic sensitivity before initiating immunotherapy or desensitization shots
- Test for specific allergic sensitivity when skin testing is unreliable (patients taking long-acting antihistamines may have false negative skin test)

RESULT: Different scoring systems are used in the interpretation of RAST results.

Increased in:

- ***IgE is the antibody that primarily responds to conditions that stimulate an allergic response and elevations are expected***
- Allergic rhinitis
- Anaphylaxis
- Asthma (exogenous)
- Atopic dermatitis
- *Echinococcus* infection
- Eczema
- Hay fever
- Hookworm infection
- Latex allergy

- Schistosomiasis
- Visceral larva migrans

Decreased in:

- Asthma (endogenous)
- Pregnancy
- Radiation therapy

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Recent radioactive scans or radiation within 1 week of the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify types of allergens that may be responsible for causing an allergic response.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and respiratory system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Indicate the specific allergen group to be tested on the specimen requisition. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding and hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations* should be given to diet if food allergies are present. Lifestyle adjustments may be necessary depending on the specific allergens identified.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include arterial/alveolar oxygen ratio, blood gases, complete blood count, eosinophil count, fecal analysis, hypersensitivity pneumonitis, IgE, and PFT.
- ▶ See the Immune and Respiratory System tables for related tests by body system.

Alveolar/Arterial Gradient and Arterial/Alveolar Oxygen Ratio

A

SYNONYM/ACRONYM: Alveolar-arterial difference, A/a gradient, a/A ratio.

SPECIMEN: Arterial blood (1 mL) collected in a heparinized syringe. Specimen should be transported tightly capped and in an ice slurry.

REFERENCE VALUE: (Method: Selective electrodes that measure pO_2 and pCO_2)

Alveolar/arterial gradient	Less than 10 mm Hg at rest (room air) 20–30 mm Hg at maximum exercise activity (room air)
Arterial/alveolar oxygen ratio	Greater than 0.75 (75%)

DESCRIPTION: A test of the ability of oxygen to diffuse from the alveoli into the lungs is of use when assessing a patient's level of oxygenation. This test can help identify the cause of hypoxemia (low oxygen levels in the blood) and intrapulmonary shunting that might result from one of the following three situations: ventilated alveoli without perfusion, unventilated alveoli with perfusion, or collapse of alveoli and associated blood vessels. Information regarding the alveolar/arterial (A/a) gradient can be estimated indirectly using the partial pressure of oxygen (pO_2) (obtained from blood gas analysis) in a simple mathematical formula:

$$\text{A/a gradient} = pO_2 \text{ in alveolar air (estimated)} - pO_2 \text{ in arterial blood (measured)}$$

An estimate of alveolar pO_2 is accomplished by subtracting the water vapor pressure from the barometric pressure, multiplying the resulting pressure by the fraction of inspired oxygen

(FIO_2 ; percentage of oxygen the patient is breathing), and subtracting this from 1.25 times the arterial partial pressure of carbon dioxide (pCO_2). The gradient is obtained by subtracting the patient's arterial pO_2 from the calculated alveolar pO_2 :

$$\text{Alveolar } pO_2 = [(\text{barometric pressure} - \text{water vapor pressure}) \times FIO_2] - [1.25 \times pCO_2]$$

$$\text{A/a gradient} = \text{arterial } pO_2 \text{ (measured)} - \text{alveolar } pO_2 \text{ (estimated)}$$

The arterial/alveolar (a/A) ratio reflects the percentage of alveolar pO_2 that is contained in arterial pO_2 . It is calculated by dividing the arterial pO_2 by the alveolar pO_2

$$a/A = paO_2/pAO_2$$

The A/a gradient increases as the concentration of oxygen the patient inspires increases. If the gradient is abnormally high, either there is a problem with the ability of oxygen to pass across the alveolar membrane or oxygenated blood is being mixed with

nonoxygenated blood. The a/A ratio is not dependent on FIO_2 ; it does not increase with a corresponding increase in inhaled oxygen. For patients on a mechanical ventilator with a changing FIO_2 , the a/A ratio can be used to determine if oxygen diffusion is improving.

INDICATIONS:

- Assess intrapulmonary or coronary artery shunting
- Assist in identifying the cause of hypoxemia

RESULT:

Increased in:


- Acute respiratory distress syndrome (ARDS) (*due to thickened edematous alveoli*)
- Atelectasis (*due to mixing oxygenated and unoxygenated blood*)
- Arterial-venous shunts (*due to mixing oxygenated and unoxygenated blood*)
- Bronchospasm
- Chronic obstructive pulmonary disease
- Congenital cardiac septal defects (*due to mixing oxygenated and unoxygenated blood*)
- Underventilated alveoli (*mucus plugs*)
- Pneumothorax
- Pulmonary edema (*due to thickened edematous alveoli*)
- Pulmonary embolus
- Pulmonary fibrosis (*due to thickened edematous alveoli*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Specimens should be collected before administration of oxygen therapy or antihistamines.
- The temperature of the patient should be noted and reported to the laboratory if significantly elevated or depressed so that

measured values can be corrected to actual body temperature.


- Exposure of sample to room air affects test results.
- Values normally increase with increasing age (see monograph titled “Blood Gases”).
-  Samples for A/a gradient evaluation are obtained by arterial puncture, which carries a risk of bleeding, especially in patients with bleeding disorders or who are taking medications for a bleeding disorder.
- Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results. Specimens should always be transported to the laboratory as quickly as possible after collection. Delay in transport of the sample or transportation without ice may affect test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assess effective delivery of oxygen by comparing the difference between oxygen levels in the arteries and the alveoli of the lungs.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ♦ Obtain a history of the patient's cardiovascular and respiratory systems, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests, diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the

appropriate number of days prior to a surgical procedure.

- ▶ Indicate the type of oxygen, mode of oxygen delivery, and delivery rate as part of the test requisition process. Wait 30 min after a change in type or mode of oxygen delivery or rate for specimen collection.
- ▶ Review the procedure with the patient, and advise rest for 30 min before specimen collection. Address concerns about pain and explain that an arterial puncture may be painful. The site may be anesthetized with 1% to 2% lidocaine before puncture. Inform the patient that specimen collection usually takes 10 to 15 min. The person collecting the specimen should be notified beforehand if the patient is receiving anticoagulant therapy, or taking aspirin or other natural products that may prolong bleeding from the puncture site.
- ▶  If the sample is to be collected by radial artery puncture, perform an Allen test before puncture to ensure that the patient has adequate collateral circulation to the hand. The modified Allen test is performed as follows: extend the patient's wrist over a rolled towel. Ask the patient to make a fist with the hand extended over the towel. Use the second and third fingers to locate the pulses of the ulnar and radial arteries on the palmar surface of the wrist. (The thumb should not be used to locate these arteries because it has a pulse.) Compress both arteries, and ask the patient to open and close the fist several times until the palm turns pale. Release pressure on the ulnar artery only. Color should return to the palm within 5 sec if the ulnar artery is functioning. This is a positive Allen test, and blood gases may be drawn from the radial artery site. The Allen test should then be performed on the opposite hand. The hand to which color is restored fastest has better circulation and should be selected for specimen collection.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ Prepare an ice slurry in a cup or plastic bag to have ready for immediate transport of the specimen to the laboratory.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection.
- ▶ Perform an arterial puncture, and collect the specimen in an air-free heparinized syringe. There is no demonstrable difference in results between samples collected in plastic syringes and samples collected in glass syringes. It is very important that no room air be introduced into the collection container, because the gases in the room and in the sample will begin equilibrating immediately. The end of the syringe must be stoppered immediately after the needle is withdrawn and removed from the puncture site. Apply a pressure dressing over the puncture site. Samples should be mixed by gentle rolling of the syringe to ensure proper mixing of the heparin with the sample, which will prevent the formation of small clots leading to rejection of the sample. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag. Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Pressure should be applied to the puncture site for at least 5 min in the unanticoagulated patient and for at least 15 min in the case of a patient receiving anticoagulant therapy.
- ▶ Observe puncture site for bleeding or hematoma formation. Apply pressure bandage.

- ▶ Teach the patient breathing exercises to assist with the appropriate exchange of oxygen and carbon dioxide.
- ▶ Administer oxygen, if appropriate.
- ▶ Teach the patient how to properly use incentive spirometry or nebulizer, if ordered.
- ▶ Intervene appropriately for hypoxia and ventilatory disturbances.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor

progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include allergen-specific IgE, α_1 -antitrypsin, α_1 -antitrypsin phenotyping, blood gases, chest x-ray, D-dimer, echocardiography, eosinophil count, fibrinogen, hypersensitivity pneumonitis, IgE, potassium, PFT, and sodium.
- ▶ See the Cardiovascular and Respiratory System tables in the back of the book for related tests by body system.

Alzheimer's Disease Markers

SYNONYM/ACRONYM: CSF tau protein and β -amyloid-42, AD.

SPECIMEN: Cerebrospinal fluid (CSF) (1 to 2 mL) collected in a plain plastic conical tube.

REFERENCE VALUE: (Method: Enzyme-linked immunosorbent assay) Simultaneous tau protein and β -amyloid-42 measurements in CSF are used in conjunction with biochemical markers of Alzheimer's disease (AD). Scientific studies indicate that a combination of elevated tau protein and decreased β -amyloid-42 protein levels are consistent with the presence of AD. Values are highly dependent on the reagents and standards used in the assay. Ranges vary among laboratories; the testing laboratory should be consulted for interpretation of results.

DESCRIPTION: AD is the most common cause of dementia in the elderly population. AD is a disorder of the central nervous system (CNS) that results in progressive and profound memory loss followed by loss of cognitive abilities and death. It may follow years of progressive formation of amyloid plaques and brain tangles, or it may appear as an early-onset form of the disease. Two recognized pathologic features of AD are neurofibrillary tangles and

amyloid plaques found in the brain. Abnormal forms of the microtubule-associated tau protein are the main component of the classic neurofibrillary tangles found in patients with AD. Tau protein concentration is believed to reflect the number of neurofibrillary tangles and may be an indication of the severity of the disease. β -amyloid-42 is a free-floating protein normally present in CSF. It is believed to accumulate in the CNS of patients with AD, causing

the formation of amyloid plaques on brain tissue. The result is that these patients have lower CSF values compared to age-matched non-AD control subjects. Recent research utilizing bio-barcode technology is investigating an association between increased levels of amyloid-beta-derived diffusible ligand (ADDL) in CSF and progression of AD.

INDICATIONS:

- Assist in establishing a diagnosis of AD

RESULT:

Decreased in:

βAmyloid-42 is decreased up to 50% of normal control

- AD (accumulation in brain with corresponding decrease in CSF)
- Creutzfeldt-Jakob disease

Increased in:

Tau protein is increased

- AD

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Some patients with AD may have normal levels of tau protein because of an insufficient number of neurofibrillary tangles.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in predictive testing for or confirmation of Alzheimer's disease, and to monitor progression of and therapy for the disease.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's neurologic system, symptoms, and results of previously performed laboratory tests, diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that the procedure will be performed by a health care provider (HCP) trained to perform the procedure and takes approximately 20 min. Address concerns about pain and explain that there may be some discomfort during the lumbar puncture. Inform the patient that a stinging sensation may be felt as the local anesthetic is injected. Instruct the patient to report any pain or other sensations that may require repositioning of the spinal needle.
- ▶ Inform the patient that the position required for the lumbar puncture may be awkward but that someone will assist. Stress the importance of remaining still and breathing normally throughout the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection.

- ▶ Record baseline vital signs, and assess neurologic status. Protocols may vary from facility to facility.
 - ▶ To perform a lumbar puncture, position the patient in the knee-chest position at the side of the bed. Provide pillows to support the spine or for the patient to grasp. The sitting position is an alternative. In this position, the patient must bend the neck and chest to the knees.
 - ▶ Prepare the site (usually between L3 and L4 or L4 and L5) with povidone-iodine, and drape the area.
 - ▶ A local anesthetic is injected. Using sterile technique, the HCP inserts the spinal needle through the spinous processes of the vertebrae and into the subarachnoid space. The stylet is removed. CSF drips from the needle if it is properly placed.
 - ▶ Attach the stopcock and manometer, and measure initial CSF pressure. Normal pressure for an adult in the lateral recumbent position is 90 to 180 mm H₂O. These values depend on the body position and are different in a horizontal or sitting position.
 - ▶ If the initial pressure is elevated, the HCP may perform Queckenstedt's test. To perform this test, apply pressure to the jugular vein for about 10 sec. CSF pressure usually rises in response to the occlusion, then rapidly returns to normal within 10 sec after the pressure is released. Sluggish response may indicate CSF obstruction.
 - ▶ Obtain CSF, and place in specimen tubes. Take a final pressure reading, and remove the needle. Clean the puncture site with an antiseptic solution, and apply a small bandage.
 - ▶ Promptly transport the specimen to the laboratory for processing and analysis.
- ▶ with baseline values. Protocols may vary from facility to facility.
 - ▶ Administer fluids, if permitted, to replace lost CSF and help prevent or relieve headache, which is a side effect of lumbar puncture.
 - ▶ Check the puncture site for leakage, and frequently monitor body signs, such as temperature and blood pressure.
 - ▶ Position the patient flat, either on the back or abdomen, although some HCPs allow 30 degrees of elevation. Maintain this position for 8 hr. Changing position is acceptable as long as the body remains horizontal.
 - ▶ Observe the patient for neurologic changes, such as altered level of consciousness, change in pupils, reports of tingling or numbness, and irritability.
 - ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient and family members regarding access to counseling and other supportive services. Provide contact information if desired, for the Alzheimer's Association (www.alz.org).
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ After lumbar puncture, monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take the temperature every 4 hr for 24 hr. Compare

RELATED MONOGRAPHS:

- ▶ Related tests include evoked brain potentials, MRI brain, and PET scan brain.
- ▶ See the Musculoskeletal System table at the back of the book for related tests by body system.

Amino Acid Screen, Blood

SYNONYM/ACRONYM: N/A.

SPECIMEN: Plasma (1 mL) collected in a green-top (heparin) tube.

REFERENCE VALUE: (Method: Chromatography) There are numerous amino acids. The following table includes those most frequently screened. All units are nanomoles per milliliter (nmol/mL).

Age	Alanine	β -Alanine	Anserine	α -Amino-adipic Acid	α -Amino-N-butyric Acid
Premature	212–504	0	–	0	14–52
Newborn– 1 mo	131–710	0–10	0	0	8–24
2 mo–2 yr	143–439	0–7	0	0	3–26
2–18 yr	152–547	0–7	0	0	4–31
Adult	177–583	0–12	0	0–6	5–41
Age	γ -Amino-butyric Acid	γ -Aminoiso-butyric Acid	Arginine	Asparagine	Aspartic Acid
Premature	0	0	34–96	90–295	24–50
Newborn– 1 mo	0–2	0	6–140	29–132	20–129
2 mo–2 yr	0	0	12–133	21–95	0–23
2–18 yr	0	0	10–140	23–112	1–24
Adult	0	0	15–128	35–74	1–25
Age	Carnosine	Citrulline	Cystathionine	Cystine	Ethanol-amine
Premature	–	20–87	5–10	15–70	–
Newborn– 1 mo	0–19	10–45	0–3	17–98	0–115
2 mo–2 yr	0	3–35	0–5	16–84	0–4
2–18 yr	0	1–46	0–3	5–45	0–7
Adult	0	12–55	0–3	5–82	0–153
Age	Glutamic Acid	Glutamine	Glycine	Histidine	Homo-cystine
Premature	107–276	248–850	298–602	72–134	3–20
Newborn– 1 mo	62–620	376–709	232–740	30–138	00
2 mo–2 yr	10–133	246–1182	81–436	41–101	0
2–18 yr	5–150	254–823	127–341	41–125	0–5
Adult	10–131	205–756	151–490	72–124	0

(table continues on page 36)

Age	Hydroxy-lysine	Hydroxy-proline	Isoleucine	Leucine	Lysine
Premature	0	0–80	23–85	151–220	128–255
Newborn–1 mo	0–7	0–91	26–91	48–160	92–325
2 mo–2 yr	0–7	0–63	31–86	47–155	52–196
2–18 yr	0–2	3–45	22–107	49–216	48–284
Adult	0	0–53	30–108	72–201	116–296

Age	Methionine	1-Methyl-histidine	3-Methyl-histidine	Ornithine	Phenylalanine
Premature	37–91	4–28	5–33	77–212	98–213
Newborn–1 mo	10–60	0–43	0–5	48–211	38–137
2 mo–2 yr	9–42	0–44	0–5	22–103	31–75
2–18 yr	7–47	0–42	0–5	10–163	26–91
Adult	10–42	0–39	0–8	48–195	35–85

Age	Phospho-ethanolamine	Phospho-serine	Proline	Sarcosine	Serine
Premature	5–35	10–45	92–310	0	127–248
Newborn–1 mo	3–27	7–47	110–417	0–625	99–395
2 mo–2 yr	0–6	1–20	52–298	0	71–186
2–18 yr	0–69	1–30	59–369	0–9	69–187
Adult	0–40	2–14	97–329	0	58–181

Age	Taurine	Threonine	Tryptophan	Tyrosine	Valine
Premature	151–411	150–330	28–136	147–420	99–220
Newborn–1 mo	46–492	90–329	0–60	55–147	86–190
2 mo–2 yr	15–143	24–174	23–71	22–108	64–294
2–18 yr	10–170	35–226	0–79	24–115	74–321
Adult	54–210	60–225	10–140	34–112	119–336

DESCRIPTION: Testing for specific aminoacidopathies is generally performed on infants after an initial screening test with abnormal results. Certain congenital enzyme deficiencies interfere with normal amino acid metabolism and cause excessive accumulation of or deficiencies in amino acid levels. The major genetic disorders include phenylketonuria, tyrosinuria, and alcaptonuria, a defect in the phenylalanine-tyrosine conversion pathway. Renal aminoaciduria is also

associated with conditions marked by defective tubular reabsorption from congenital disorders, such as hereditary fructose intolerance, cystinuria, and Hartnup disease. Early diagnosis and treatment of certain aminoacidopathies can prevent mental retardation, reduced growth rates, and various unexplained symptoms. In most cases when plasma levels are elevated, urine levels are also elevated. Amino acid quantitation from plasma specimens is more informative, less variable, and less

prone to analytic interference than from urine specimens. Urine specimens may be required to assist in the identification of disorders involving defective renal transport, where elevated levels are only manifested in the urine. Values are age-dependent. Amino acid concentrations demonstrate a significant circadian rhythm with values being lowest in the morning and highest in midafternoon.

INDICATIONS:

- Assist in the detection of noninherited disorders evidenced by elevated amino acid levels
- Detect congenital errors of amino acid metabolism

RESULT:

Increased in:

- **Increased amino acid accumulation (total amino acids) occurs when a specific enzyme deficiency prevents its catabolism, with liver disease, or when there is impaired clearance by the kidneys:**

Aminoacidopathies (*usually inherited; specific amino acids are implicated*)

Burns
Diabetes
Fructose intolerance (*hereditary*)
Malabsorption
Renal failure (acute or chronic)
Reye's syndrome
Severe liver damage
Shock

Decreased in:

- **Decreased (total amino acids) in conditions that result in increased renal excretion or insufficient protein intake or synthesis:**

Adrenocortical hyperfunction
Carcinoid syndrome
Fever
Glomerulonephritis
Hartnup disease
Huntington's chorea
Malnutrition

Nephrotic syndrome
Pancreatitis (acute)
Polycystic kidney disease
Rheumatoid arthritis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase plasma amino acid levels include amino acids, bismuth salts, glucocorticoids, levarterenol, and 11-oxyteroids.
- Drugs that may decrease plasma amino acid levels include diethylstilbestrol, epinephrine, insulin, and progesterone.
- Amino acids exhibit a strong circadian rhythm; values are highest in the afternoon and lowest in the morning. Protein intake does not influence diurnal variation but significantly affects absolute concentrations.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient (and/or caregiver) that the test is used to screen for congenital errors of protein metabolism and transport.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and hepatobiliary systems and the patient's or parents' reproductive system as it relates to genetic disease, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- Review the procedure with the patient (and/or caregiver). Inform the patient (and/or caregiver) that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- Sensitivity to social and cultural issues**, is important in providing psychological support before, during, and after the procedure.
- Instruct the patient to fast for 12 hr prior to the procedure.
- There are no fluid or medication restrictions unless by medical direction.

INTRATEST:

- Ensure that the patient has complied with dietary and other pretesting preparations; assure that food has been restricted for at least 12 hr prior to the procedure.
- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Instruct the patient (and/or caregiver) to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement. The caregiver may assist in preventing unnecessary movement.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient (and/or caregiver).
- Instruct the patient to resume usual diet as directed by the HCP.
- Nutritional considerations:** Instruct the patient (and/or caregiver) in special dietary modifications, as appropriate to

treat deficiency, or refer caregiver to a qualified nutritionist. Amino acids are classified as essential (i.e., must be present simultaneously in sufficient quantities); conditionally or acquired essential (i.e., under certain stressful conditions, they become essential); and nonessential (i.e., can be produced by the body, when needed, if diet does not provide them). Essential amino acids include lysine, threonine, histidine, isoleucine, methionine, phenylalanine, tryptophan, and valine. Conditionally essential amino acids include cysteine, tyrosine, arginine, citrulline, taurine, and carnitine. Nonessential amino acids include alanine, glutamic acid, aspartic acid, glycine, serine, proline, glutamine, and asparagine. A high intake of specific amino acids can cause other amino acids to become essential.

- Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient (and/or caregiver) regarding access to genetic or other counseling services. Provide contact information, if desired, for the March of Dimes (www.marchofdimes.com) or the state department of health newborn screening program.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ammonia and urine amino acid screen.
- See the Genitourinary, Hepatobiliary, and Reproductive System tables at the back of the book for related tests by body system.

Amino Acid Screen, Urine

A

SYNONYM/ACRONYM: N/A.

SPECIMEN: Urine (10 mL) from a random or timed specimen collected in a clean plastic collection container with hydrochloric acid as a preservative.

REFERENCE VALUE: (Method: Chromatography) There are numerous amino acids. The following table includes those most frequently screened. All units are nanomoles per milligram (nmol/mg) creatinine.

Age	Alanine	β -Alanine	Anserine	α -Amino-adipic Acid	α -Amino-N-butyric Acid
Premature	1320–4040	1020–3500	–	70–460	50–710
Newborn– 1 mo	982–3055	25–288	0–3	0–180	8–65
2 mo–2 yr	767–6090	0–297	0–5	45–268	30–136
2–18 yr	231–915	0–65	0	2–88	0–77
Adult	240–670	0–130	0	40–110	0–90
Age	γ -Amino-butyric Acid	β -Aminoiso-butyric Acid	Arginine	Asparagine	Aspartic Acid
Premature	20–260	50–470	190–820	1350–5250	580–1520
Newborn– 1 mo	0–15	421–3133	35–214	185–1550	336–810
2 mo–2 yr	0–105	802–4160	38–165	252–1280	230–685
2–18 yr	15–30	291–1482	31–109	72–332	0–120
Adult	15–30	10–510	10–90	99–470	60–240
Age	Carnosine	Citrulline	Cystathionine	Cystine	Ethanolamine
Newborn– 1 mo	97–665	27–181	16–147	212–668	840–3400
2 mo–2 yr	203–635	22–180	33–470	68–710	0–2230
2–18 yr	72–402	10–99	0–26	25–125	0–530
Adult	10–90	8–50	20–50	43–210	0–520
Age	Glutamic Acid	Glutamine	Glycine	Histidine	Homocystine
Premature	380–3760	520–1700	7840–23,600	1240–7240	580–2230
Newborn– 1 mo	70–1058	393–1042	5749–16,423	908–2528	0–88
2 mo–2 yr	54–590	670–1562	3023–11,148	815–7090	6–67
2–18 yr	0–176	369–1014	897–4500	644–2430	0–32
Adult	39–330	190–510	730–4160	460–1430	0–32

(table continues on page 40)

Age	Hydroxy-lysine	Hydroxy-proline	Isoleucine	Leucine	Lysine
Premature	—	560–5640	250–640	190–790	1860–15,460
Newborn— 1 mo	10–125	40–440	125–390	78–195	270–1850
2 mo–2 yr	0–97	0–4010	38–342	70–570	189–850
2–18 yr	40–102	0–3300	10–126	30–500	153–634
Adult	40–90	0–26	16–180	30–150	145–634

Age	Methionine	1-Methyl-histidine	3-Methyl-histidine	Ornithine	Phenyl-alanine
Premature	500–1230	170–880	420–1340	260–3350	920–2280
Newborn— 1 mo	342–880	96–499	189–680	118–554	91–457
2 mo–2 yr	174–1090	106–1275	147–391	55–364	175–1340
2–18 yr	16–114	170–1688	182–365	31–91	61–314
Adult	38–210	170–1680	160–520	20–80	51–250

Age	Phospho-ethanolamine	Phospho-serine	Proline	Sarcosine	Serine
Premature	80–340	500–1690	1350–10,460	0	1680–6000
Newborn— 1 mo	0–155	150–339	370–2323	0–56	1444–3661
2 mo–2 yr	108–533	112–304	254–2195	30–358	845–3190
2–18 yr	18–150	70–138	0	0–26	362–1100
Adult	20–100	40–510	0	0–80	240–670

Age	Taurine	Threonine	Tryptophan	Tyrosine	Valine
Premature	5190–23,620	840–5700	0	1090–6780	180–890
Newborn— 1 mo	1650–6220	445–1122	0	220–1650	113–369
2 mo–2 yr	545–3790	252–1528	0–93	333–1550	99–316
2–18 yr	639–1866	121–389	0–108	122–517	58–143
Adult	380–1850	130–370	0–70	90–290	27–260

RESULT:**Increased in:**

• **Increased amino acid accumulation (total amino acids) occurs when a specific enzyme deficiency prevents its catabolism or when there is impaired clearance by the kidneys:**

• **Primary causes (inherited):**

Aminoaciduria (specific)

Cystinosis (*may be masked because of decreased glomerular filtration rate, so values may be in normal range*)

Fanconi's syndrome

Fructose intolerance

Galactosemia

Hartnup disease

Lactose intolerance

Lowe's syndrome

Maple syrup urine disease

Tyrosinemia type I

Tyrosinosis

Wilson's disease

• **Secondary causes (noninherited):**

Acute leukemia

Chronic renal failure (*reduced GFR*)

Chronic renal failure

Diabetic ketosis

Epilepsy (*transient increase due to disturbed renal function during grand mal seizure*)

Folic acid deficiency
 Hyperparathyroidism
 Liver necrosis and cirrhosis
 Multiple myeloma
 Muscular dystrophy (progressive)
 Osteomalacia (*secondary to parathyroid hormone excess*)
 Pernicious anemia
 Thalassemia major

Vitamin deficiency (*B, C, and D; vitamin D–deficiency rickets, vitamin D–resistant rickets*)
 Viral hepatitis (*reflects the degree of hepatic involvement*)

Decreased in: N/A

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

δ -Aminolevulinic Acid

SYNONYM/ACRONYM: δ -ALA.

SPECIMEN: Urine (25 mL) from a timed specimen collected in a dark plastic container with glacial acetic acid as a preservative.

REFERENCE VALUE: (Method: Spectrophotometry)

Conventional Units	SI Units (Conventional Units \times 7.626)
1.5–7.5 mg/24 hr	11.4–57.2 micromol/24 hr

DESCRIPTION: δ -Aminolevulinic acid (δ -ALA) is involved in the formation of porphyrins. Toxins including alcohol, lead, and other heavy metals can inhibit porphyrin synthesis. Accumulated δ -ALA is excreted in urine. Symptoms of the acute phase of intermittent porphyrias include abdominal pain, nausea, vomiting, neuromuscular signs and symptoms, constipation, and occasionally psychotic behavior. Hemolytic anemia may also exhibit during the acute phase. δ -ALA is a test of choice in the diagnosis of acute intermittent porphyria. Although lead poisoning can cause increased urinary excretion, the measurement of δ -ALA is not useful to indicate lead toxicity because it is not detectable in the urine until the blood lead level approaches and exceeds 40 mcg/dL.

INDICATIONS:

- Assist in the diagnosis of porphyrias

RESULT:

Increased in:

- *Inhibition of the enzymes involved in porphyrin synthesis results in accumulation of δ -ALA.*
- Acute porphyrias
- Aminolevulinic acid dehydrase deficiency
- Hereditary tyrosinemia
- Lead poisoning

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase δ -ALA levels include penicillins.
- Cimetidine may decrease δ -ALA levels.
- Numerous drugs are suspected as potential initiators of attacks

of acute porphyria, but those classified as unsafe for high-risk individuals include aminopyrine, apronalide, barbiturates, chlor-diazepoxide, chlorpropamide, diazepam, dichloralphenazone, ergot preparations, glutethimide, griseofulvin, hydantoin derivatives, isopropyl dipyrone, meprobamate, methyldopa, methylsulfonal, methyprylone, oral contraceptives, pentazocine, phenytoin, progestogens, succinimide, sulfomethane, and tolbutamide.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to diagnose porphyrias.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection

container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started, and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period. Monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection. If the specimen contains less than what was

recorded as output, some urine may have been discarded, invalidating the test.

- ▶ Include on the specimen collection container's label the amount of urine as well as test start and stop times. Note the ingestion of any medications that may affect test results.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count, erythrocyte protoporphyrin (free), lead and porphyrins urine.
- ▶ See the Hematopoietic System table in the back of the book for related tests by body system.

Ammonia

SYNONYM/ACRONYM: NH₃.

SPECIMEN: Plasma (1 mL) collected in completely filled lavender- (EDTA) or green-top (Na or Li heparin) tube. Specimen should be transported tightly capped and in an ice slurry.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 0.714)
Newborn	90–150 mcg/dL	64–107 micromol/L
Adult Male	27–102 mcg/dL	19–73 micromol/L
Adult Female	19–87 mcg/dL	14–62 micromol/L

DESCRIPTION: Blood ammonia (NH₃) comes from two sources: deamination of amino acids during protein metabolism and degradation of proteins by colon bacteria. The liver converts ammonia in the portal blood to urea, which is excreted by the kidneys. When liver

function is severely compromised, especially in situations in which decreased hepatocellular function is combined with impaired portal blood flow, ammonia levels rise. Ammonia is potentially toxic to the central nervous system.

INDICATIONS:

- Evaluate advanced liver disease or other disorders associated with altered serum ammonia levels
- Identify impending hepatic encephalopathy with known liver disease
- Monitor the effectiveness of treatment for hepatic encephalopathy, indicated by declining levels
- Monitor patients receiving hyperalimentation therapy

RESULT:**Increased in:**

- Gastrointestinal hemorrhage (**decreased blood volume prevents ammonia from reaching the liver to be metabolized**)
- Genitourinary tract infection with distention and stasis (**decreased renal excretion; levels accumulate in the blood**)
- Hepatic coma (**insufficient functioning liver cells to metabolize ammonia; levels accumulate in the blood**)
- Inborn enzyme deficiency (**inability to metabolize ammonia**)
- Liver failure, late cirrhosis (**insufficient functioning liver cells to metabolize ammonia**)
- Reye's syndrome (**insufficient functioning liver cells to metabolize ammonia**)
- Total parenteral nutrition (**ammonia is generated from protein metabolism**)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase ammonia levels include asparaginase, chlorothiazide, fibrin hydrolysate, furosemide, hydroflumethiazide, thiazides, and valproic acid.
- Drugs/organisms that may decrease ammonia levels include diphenhydramine, kanamycin, neomycin,

tetracycline, and *Lactobacillus acidophilus*.

- Hemolysis falsely increases ammonia levels because intracellular ammonia levels are three times higher than plasma.
- Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results. The specimen should be collected on ice; the collection tube should be filled completely, and then kept tightly stoppered. Ammonia increases rapidly in the collected specimen, so analysis should be performed within 20 min of collection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess liver function, particularly in the diagnosis of urea cycle deficiencies in neonates and the identification of Reye's syndrome.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal, genitourinary, and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe the venipuncture site for bleeding or hematoma formation and secure the gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Increased ammonia levels may be associated with liver disease. Dietary recommendations may be indicated, depending on the severity of the condition. A low-protein diet may be in order if the patient's liver has lost the ability to process the end products of protein metabolism. A diet of soft foods may be required if

esophageal varices have developed. Ammonia levels may be used to determine whether protein should be added to or reduced from the diet. Patients should be encouraged to eat simple carbohydrates and emulsified fats (as in homogenized milk or eggs), as opposed to complex carbohydrates (e.g., starch, fiber, and glycogen [animal carbohydrates]) and complex fats, which would require additional bile to emulsify them so that they could be used. The cirrhotic patient should be carefully observed for the development of ascites, in which case fluid and electrolyte balance requires strict attention.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include acetaminophen, ALT, albumin, anion gap, AST, bilirubin, biopsy liver, blood gases, BUN, blood calcium, complete blood count, CT biliary tract and liver, CT pelvis, cystometry, cystoscopy, EGD, electrolytes, GI blood loss scan, glucose, IVP, MRI pelvis, ketones, lactic acid, Meckel's scan, osmolality, protein, PT/INR, uric acid, and US pelvis.
- ▶ See the Gastrointestinal, Genitourinary, and Hepatobiliary System tables at the back of the book for related tests by body system.

Amniotic Fluid Analysis

SYNONYM/ACRONYM: N/A.

SPECIMEN: Amniotic fluid (10 to 20 mL) collected in a clean amber glass or plastic container.

REFERENCE VALUE: (Method: Macroscopic observation of fluid for color and appearance, immunochemiluminometric assay [ICMA] for α_1 -fetoprotein, electrophoresis for acetylcholinesterase, spectrophotometry for creatinine and bilirubin, chromatography for lecithin/sphingomyelin [L/S] ratio and phosphatidylglycerol, tissue culture for chromosome analysis, dipstick for leukocyte esterase, and automated cell counter for white blood cell count and lamellar bodies)

Test	Reference Value
Color	Colorless to pale yellow
Appearance	Clear
α_1 -Fetoprotein	Less than 2.0 MoM*
Acetylcholinesterase	Absent
Creatinine	1.8–4.0 mg/dL at term
Bilirubin	Less than 0.075 mg/dL in early pregnancy Less than 0.025 mg/dL at term
L/S ratio	Greater than 2:1 at term
Phosphatidylglycerol	Present at term
Chromosome analysis	Normal karyotype
White blood cell count	None seen
Leukocyte esterase	Negative
Lamellar bodies	30,000–50,000 platelet equivalents

*MoM = multiples of the median.

DESCRIPTION: Amniotic fluid is formed in the membranous sac that surrounds the fetus. The total volume of fluid at term is 500 to 2500 mL. In amniocentesis, fluid is obtained by ultrasound-guided needle aspiration from the amniotic sac. This procedure is generally performed between 14 and 16 weeks' gestation for accurate interpretation of test results, but it also can be done between 26 and 35 weeks' gestation if fetal distress is suspected. Amniotic fluid is tested to identify genetic and neural tube defects, hemolytic diseases of the newborn, fetal infection, fetal renal malfunction, or maturity of the fetal lungs (see monograph titled "Lecithin/Sphingomyelin Ratio"). Several rapid tests are also used to differentiate amniotic fluid from other body fluids in a vaginal specimen when premature rupture of membranes (PROM) is suspected.

A vaginal swab obtained from the posterior vaginal pool can be used to perform a rapid, waived procedure to aid in the assessment of PROM. Nitrazine paper impregnated with an indicator dye will produce a color change indicative of vaginal pH. Normal vaginal pH is acidic (4.5–6.0) and the color of the paper will not change. Amniotic fluid has an alkaline pH (7.1–7.3) and the paper will turn a blue color. False positive results occur in the presence of semen, blood, alkaline urine, vaginal infection, or if the patient is receiving antibiotics. The amniotic fluid crystallization or Fern test is based on the observation of a fern pattern when amniotic fluid is placed on a glass slide and allowed to air dry. The fern pattern is due to the protein and sodium chloride content of the amniotic fluid. False positive results occur in the presence of blood urine or cervical

mucus. Both of these tests can produce false negative results if only a small amount of fluid is leaked. The reliability of results is also significantly diminished with the passage of time (greater than 24 hr). AmniSure is an immunoassay that can be performed on a vaginal swab sample. It is a rapid test that detects placental alpha microglobulin-1 protein (PAMG-1), which is found in high concentrations in amniotic fluid. AmniSure does not demonstrate the high frequency of false positive and negative results inherent with the pH and fern tests.

INDICATIONS:

- Assist in the diagnosis of (in utero) metabolic disorders, such as cystic fibrosis; or errors of lipid, carbohydrate, or amino acid metabolism.
- Detect infection secondary to ruptured membranes.
- Detect fetal ventral wall defects.
- Determine fetal maturity when preterm delivery is being considered. Fetal maturity is indicated by an L/S ratio of 2:1 or greater (see monograph titled “Lecithin/Sphingomyelin Ratio”).
- Determine fetal gender when the mother is a known carrier of a sex-linked abnormal gene that could be transmitted to male offspring, such as hemophilia or Duchenne’s muscular dystrophy.
- Determine the presence of fetal distress in late-stage pregnancy.
- Evaluate fetus in families with a history of genetic disorders, such as Down syndrome, Tay-Sachs disease, chromosome or enzyme anomalies, or inherited hemoglobinopathies.
- Evaluate fetus in mothers of advanced maternal age (some of the aforementioned tests are routinely requested in mothers age 35 and older).
- Evaluate fetus in mothers with a history of miscarriage or stillbirth.
- Evaluate known or suspected hemolytic disease involving the fetus in an Rh-sensitized pregnancy, indicated by rising bilirubin levels, especially after the 30th wk of gestation.
- Evaluate suspected neural tube defects, such as spina bifida or myelomeningocele, as indicated by elevated α_1 -fetoprotein (see monograph titled “ α_1 -Fetoprotein” for information related to triple-marker testing).

RESULT:

- Yellow, green, red, or brown fluid **indicates the presence of bilirubin, blood (fetal or maternal), or meconium, which indicate fetal distress or death, hemolytic disease, or growth retardation.**
- Elevated bilirubin levels **indicate fetal hemolytic disease or intestinal obstruction. Measurement of bilirubin is not usually performed before 20 to 24 weeks’ gestation because no action can be taken before then. The severity of hemolytic disease is graded by optical density (OD) zones: A value of 0.28 to 0.46 OD at 28 to 31 weeks’ gestation indicates mild hemolytic disease, which probably will not affect the fetus; 0.47 to 0.90 OD indicates a moderate effect on the fetus; and 0.91 to 1.0 OD indicates a significant effect on the fetus. A trend of increasing values with serial measurements may indicate the need for intrauterine transfusion or early delivery, depending on the fetal age. After 32 to 33 weeks’ gestation, early delivery is preferred over intrauterine transfusion, because early delivery is more effective in providing the required care to the neonate.**

- Creatinine concentration greater than 2.0 mg/dL **indicates fetal maturity (at 36 to 37 wk) if maternal creatinine is also within the expected range. This value should be interpreted in conjunction with other parameters evaluated in amniotic fluid and especially with the L/S ratio, because normal lung development depends on normal kidney development.**
- An L/S ratio less than 2:1 and absence of phosphatidylglycerol at term **indicate fetal lung immaturity and possible respiratory distress syndrome. The expected L/S ratio for the fetus of an insulin-dependent diabetic mother is higher (3.5:1).** (See monograph titled “Lecithin/Sphingomyelin Ratio.”)
- **Lamellar bodies are specialized alveolar cells in which lung surfactant is stored.** They are approximately the size of platelets. Their presence in sufficient quantities is an indicator of fetal lung maturity.
- Elevated α_1 -fetoprotein levels and presence of acetylcholinesterase **indicate a neural tube defect (see monograph titled “ α_1 -Fetoprotein”). Elevation of acetylcholinesterase is also indicative of ventral wall defects.**
- Abnormal karyotype **indicates genetic abnormality (e.g., Tay-Sachs disease, mental retardation, chromosome or enzyme anomalies, and inherited hemoglobinopathies).** (See monograph titled “Chromosome Analysis, Blood.”)
- Elevated white blood cell count and positive leukocyte esterase **are indicators of infection.**

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Bilirubin may be falsely elevated if maternal hemoglobin or

meconium is present in the sample; fetal acidosis may also lead to falsely elevated bilirubin levels.

- Bilirubin may be falsely decreased if the sample is exposed to light or if amniotic fluid volume is excessive.
- Maternal serum creatinine should be measured simultaneously for comparison with amniotic fluid creatinine for proper interpretation. Even in circumstances in which the maternal serum value is normal, the results of the amniotic fluid creatinine may be misleading. A high fluid creatinine value in the fetus of a diabetic mother may reflect the increased muscle mass of a larger fetus. If the fetus is big, the creatinine may be high, and the fetus may still have immature kidneys.
- Contamination of the sample with blood or meconium or complications in pregnancy may yield inaccurate L/S ratios.
- α_1 -Fetoprotein and acetylcholinesterase may be falsely elevated if the sample is contaminated with fetal blood.
- Karyotyping cannot be performed under the following conditions: (1) failure to promptly deliver samples for chromosomal analysis to the laboratory performing the test, or (2) improper incubation of the sample, which causes cell death.
- Amniocentesis is contraindicated in women with a history of premature labor or incompetent cervix. It is also contraindicated in the presence of placenta previa or abruptio placentae.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate fetal well-being.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's reproductive system, previous pregnancies, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Include any family history of genetic disorders such as cystic fibrosis, Duchenne's muscular dystrophy, hemophilia, sickle cell disease, Tay-Sachs disease, thalassemia, and trisomy 21. Obtain maternal Rh type. If Rh-negative, check for prior sensitization. A standard dose of Rh,₀(D) immune globulin Rhogam IM or Rhophylac IM or IV is indicated after amniocentesis; repeat doses should be considered if repeated amniocentesis is performed.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the pregnancy weeks' gestation and expected delivery date.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Warn the patient that normal results do not guarantee a normal fetus. Assure the patient that precautions to avoid injury to the fetus will be taken by localizing the fetus with ultrasound. Address concerns about pain and explain that, during the transabdominal procedure, any discomfort associated with a needle biopsy will be minimized with local anesthetics. If the patient is less than 20 weeks' gestation, instruct her to drink extra fluids 1 hr before the test and to refrain from urination. The full bladder assists in raising the uterus up and out of the way to provide better visualization during the ultrasound procedure. Patients who are at 20 weeks' gestation or beyond do not need to drink extra fluids and should void before the test, because an empty bladder is less likely to be accidentally punctured during specimen collection. Encourage relaxation and controlled breathing during the procedure to aid in reducing any mild discomfort. Inform the patient that specimen collection is

performed by a health care provider (HCP) specializing in this procedure and usually takes approximately 20 to 30 min to complete.


- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has a full bladder before the procedure if gestation is 20 wk or less; have patient void before the procedure if gestation is 21 wk or more.
- ▶ Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date, time of collection, and site location.
- ▶ Have patient remove clothes below the waist. Assist the patient to a supine position on the exam table with the abdomen exposed. Drape the patient's legs, leaving the abdomen exposed. Raise her head or legs slightly to promote comfort and to relax the abdominal muscles. If the uterus is large, place a pillow or rolled blanket under the patient's right side to prevent hypertension caused by great-vessel compression. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Record maternal and fetal baseline vital signs, and continue to monitor throughout the procedure. Monitor for uterine contractions. Monitor fetal vital signs using ultrasound. Protocols may vary from facility to facility.
- ▶ After the administration of local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.
- ▶ Have emergency equipment readily available.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.

- ▶ Assess the position of the amniotic fluid, fetus, and placenta using ultrasound.
- ▶ Assemble the necessary equipment, including an amniocentesis tray with solution for skin preparation, local anesthetic, 10- or 20-mL syringe, needles of various sizes (including a 22-gauge, 5-in. spinal needle), sterile drapes, sterile gloves, and foil-covered or amber-colored specimen collection containers.
- ▶ Cleanse suprapubic area with an antiseptic solution, and protect with sterile drapes. A local anesthetic is injected. Explain that this may cause a stinging sensation.
- ▶ A 22-gauge, 5-in. spinal needle is inserted through the abdominal and uterine walls. Explain that a sensation of pressure may be experienced when the needle is inserted. Explain to the patient how to use focused and controlled breathing for relaxation during the procedure.
- ▶ After the fluid is collected and the needle is withdrawn, apply slight pressure to the site. If there is no evidence of bleeding or other drainage, apply a sterile adhesive bandage to the site.
- ▶ Monitor the patient for complications related to the procedure (e.g., premature labor, allergic reaction, anaphylaxis).
- ▶ Instruct the patient to expect mild cramping, leakage of small amount of amniotic fluid, and vaginal spotting for up to 2 days following the procedure. Instruct the patient to report moderate to severe abdominal pain or cramps, change in fetal activity, increased or prolonged leaking of amniotic fluid from abdominal needle site, vaginal bleeding that is heavier than spotting, and either chills or fever.
- ▶ Instruct the patient to rest until all symptoms have disappeared before resuming normal levels of activity.
- ▶ Administer standard RhoGAM dose to maternal Rh-negative patients to prevent maternal Rh sensitization should the fetus be Rh-positive.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Encourage the family to seek appropriate counseling if concerned with pregnancy termination, and to seek genetic counseling if a chromosomal abnormality is determined. Decisions regarding elective abortion should take place in the presence of both parents. Provide a nonjudgmental, nonthreatening atmosphere for discussing the risks and difficulties of delivering and raising a developmentally challenged infant, as well as exploring other options (termination of pregnancy or adoption). It is also important to discuss problems the mother and father may experience (guilt, depression, anger) if fetal abnormalities are detected.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶  After the procedure, fetal heart rate and maternal life signs (i.e., heart rate, blood pressure, pulse, and respiration) should be compared with baseline values and closely monitored every 15 min for 30 to 60 min after the amniocentesis procedure. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the amniocentesis site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the amniocentesis site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to keep the site clean and change the dressing as needed.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that it may be 2 to 4 wk before all results are available. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage her

to review corresponding literature provided by a pharmacist.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include α_1 -fetoprotein, blood groups and antibodies, chromosome analysis, fetal fibronectin, Kleihauer-Betke test, L/S ratio, lupus anticoagulant antibodies, and US biophysical profile obstetric.
- Refer to the Reproductive System table at the end of the book for related tests by body system.

A

Amylase

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in a green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

Conventional & SI Units

30–110 units/L

DESCRIPTION: Amylase, a digestive enzyme, splits starch into disaccharides. Although many cells have amylase activity (e.g., liver, small intestine, ovaries, skeletal muscles), circulating amylase is derived from the parotid glands and the pancreas. Amylase is a sensitive indicator of pancreatic acinar cell damage and pancreatic obstruction. Newborns and children up to 2 y.o. have little measurable serum amylase. In the early years of life, most of this enzyme is produced by the salivary glands. Amylase can be separated into pancreatic (P_1, P_2, P_3) and salivary (S_1, S_2, S_3) isoenzymes. Isoenzyme patterns are useful in identifying

the organ source. Cyst fluid amylase levels with isoenzyme analysis is useful in differentiating pancreatic neoplasms (low enzyme concentration) and pseudocysts (high enzyme concentration).

INDICATIONS:

- Assist in the diagnosis of early acute pancreatitis; serum amylase begins to rise within 6 to 24 hr after onset and returns to normal in 2 to 7 days
- Assist in the diagnosis of macroamylasemia, a disorder seen in alcoholism, malabsorption syndrome, and other digestive problems
- Assist in the diagnosis of pancreatic duct obstruction, which causes serum amylase levels to remain elevated

- Detect blunt trauma or inadvertent surgical trauma to the pancreas
- Differentiate between acute pancreatitis and other causes of abdominal pain that require surgery

RESULT:**Increased in:**

- ***Amylase is released from any damaged cell in which it is stored so conditions that affect the pancreas and parotid glands and cause cellular destruction demonstrate elevated amylase levels.***
- Abdominal trauma
- Alcoholism (***salivary origin most likely***)
- Carcinoma of the head of the pancreas (advanced)
- Common bile duct obstruction (***accumulation in blood due to impaired pancreatic duct flow***)
- Diabetic ketoacidosis (***salivary origin***)
- Duodenal obstruction (***accumulation in blood due to leakage from the gut***)
- Ectopic pregnancy (***ectopic enzyme production by the fallopian tubes***)
- Gastric resection (***accumulation in blood due to leakage from the gut***)
- Macroamylasemia (***accumulation in blood due to inability of renal glomeruli to filter large molecules***)
- Mumps (***salivary origin***)
- Pancreatic cyst and pseudocyst
- Pancreatitis
- Parotitis
- Perforated peptic ulcer involving the pancreas
- Peritonitis (***accumulation in blood due to leakage from the gut***)
- Postoperative period
- Renal disease (***accumulation in blood due to lack of kidney excretion***)

- Some tumors of the lung and ovaries (***ectopic enzyme production***)

Decreased in:

- Hepatic disease (severe) (***may be due to lack of amino acid production necessary for enzyme manufacture***)
- Pancreatectomy
- Pancreatic insufficiency

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs and substances that may increase amylase levels include aminosalicic acid, amoxapine, azathioprine, bethanechol, calcitrol, cholinergics, chlorthalidone, cisplatin, cimetidine, clozapine, codeine, corticosteroids, diazoxide, felbamate, fentanyl, fluvastatin, glucocorticoids, hydantoin derivatives, hydrochlorothiazide, hydroflumethiazide, isoniazid, meperidine, mercaptopurine, minocycline, mirtazapine, morphine, nitrofurantoin, pegasparagase, penicillamine, pentazocine, phenylbutazone, potassium iodide, procyclidine, tetracycline, thiazide diuretics, valproic acid, zalcitabine, and zidovudine.
- Drugs that may decrease amylase levels include anabolic steroids, citrates, and fluorides.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to assess pancreatic function.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine, gastrointestinal, and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations:* Increased amylase levels may be associated with gastrointestinal disease or alcoholism. Small, frequent meals work best for patients with gastrointestinal disorders. Consideration should be given to dietary alterations in the case of gastrointestinal disorders. Usually after acute symptoms subside and bowel sounds return, patients are given a clear liquid diet, progressing to a low-fat, high-carbohydrate diet. Vitamin B₁₂ may be ordered for parenteral administration to patients with decreased levels, especially if their disease prevents adequate absorption of the vitamin. The alcoholic patient should be encouraged to avoid alcohol and to seek appropriate counseling for substance abuse.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, ALP, AST, bilirubin, cancer antigens, calcium, C-Peptide, CT pancreas, ERCP, fecal fat, GGT, lipase, magnesium, MRI pancreas, mumps serology, peritoneal fluid analysis, triglycerides, US pancreas, and complete blood count, WBC count and differential.
- ▶ See the Endocrine, Gastrointestinal, and Hepatobiliary System tables at the back of the book for related tests by body system.

Analgesic and Antipyretic Drugs: Acetaminophen, Acetylsalicylic Acid

SYNONYM/ACRONYM: *Acetaminophen* (Acephen, Apacet, Aspirin Free Anacin, Banesin, Dapa, Datriil, Dorcol, Gebapap, Halenol, Liquiprin, Meda Cap, Panadol, Redutemp, Tempra, Tylenol, Ty-Pap, Uni-Ace); *Acetylsalicylic acid* (salicylate, aspirin, Anacin, Aspergum, Bufferin, Ecotrin, Empirin, Measurin, Synalgos, ZORprin, ASA).

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Drug	Therapeutic Dose*	SI Units	Half-Life	Volume of Distribution	Protein Binding	Excretion
<i>(SI = Conventional Units × 6.62)</i>						
Acetaminophen	10–30 mcg/mL	66–199 micromol/L	1–3 hr	0.95 L/kg	20–50%	85–95% hepatic, metabo- lites, renal
<i>(SI = Conventional Units × 0.073)</i>						
Salicylate	15–20 mg/dL	1.1–1.4 mmol/L	2–3 hr	0.1–0.3 L/kg	90–95%	1° hepatic, metabo- lites, renal

*Conventional units.

DESCRIPTION: Acetaminophen is used for headache, fever, and pain relief, especially for individuals unable to take salicylate products or who have bleeding conditions. It is the analgesic of choice for children less than 13 y.o.; salicylates are avoided in this age group because of the association between aspirin and Reye's syndrome. Acetaminophen is rapidly absorbed from the gastrointestinal tract and reaches peak concentration within 30 to 60 min after administration of a therapeutic dose. It can be a silent killer because, by the time symptoms of intoxication appear 24 to 48 hr after ingestion, the antidote is ineffective. Acetylsalicylic acid

(ASA) is also used for headache, fever, and pain relief. Some patients with cardiovascular disease take small prophylactic doses. The main site of toxicity for both drugs is the liver, particularly in the presence of liver disease or decreased drug metabolism and excretion.

Many factors must be considered in interpreting drug levels, including patient age, patient weight, interacting medications, electrolyte balance, protein levels, water balance, conditions that affect absorption and excretion, and foods, herbals, vitamins, and minerals that can potentiate or inhibit the intended target concentration.

INDICATIONS:


- Suspected overdose
- Suspected toxicity
- Therapeutic monitoring

RESULT:**Increased in:**

- Acetaminophen
 - Alcoholic cirrhosis (**blood level increases due to inability of damaged liver to metabolize the drug**)
 - Liver disease (**blood level increases due to inability of damaged liver to metabolize the drug**)
 - Toxicity
- ASA
 - Toxicity

Decreased in:

- Noncompliance with therapeutic regimen

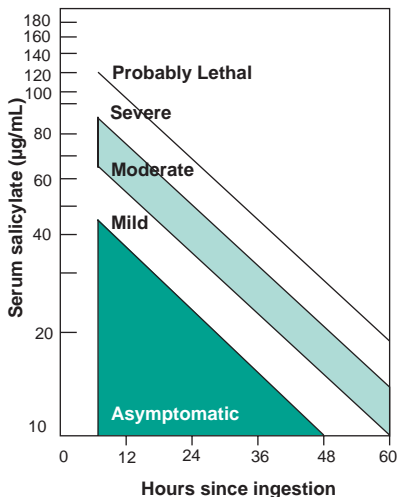
CRITICAL VALUES:  *Note:* The adverse effects of subtherapeutic levels are also important. Care should be taken to investigate signs and symptoms of too little and too much medication. Note and immediately report to the health care practitioner (HCP) any critically increased values and related symptoms.

Acetaminophen: Greater Than 150 mcg/mL (4 Hours Postingestion); Greater Than 50 mcg/mL (12 Hours Postingestion)

Signs and symptoms of acetaminophen intoxication occur in stages over a period of time. In stage I (0 to 24 hr after ingestion), symptoms may include gastrointestinal irritation, pallor, lethargy, diaphoresis, metabolic acidosis, and possibly coma. In stage II (24 to 48 hr after ingestion), signs and symptoms may include right upper quadrant abdominal pain; elevated liver enzymes, aspartate aminotransferase (AST), and alanine aminotransferase (ALT); and possible decreased renal function. In stage III

(72 to 96 hr after ingestion), signs and symptoms may include nausea, vomiting, jaundice, confusion, coagulation disorders, continued elevation of AST and ALT, decreased renal function, and coma. Intervention may include gastrointestinal decontamination (stomach pumping) if the patient presents within 6 hr of ingestion or administration of *N*-acetylcysteine (Mucomyst) in the case of an acute intoxication in which the patient presents more than 6 hr after ingestion. (See figure below.)

Pediatric Serum Salicylate Level and Severity of Intoxication Single Dose Acute Ingestion Nomogram



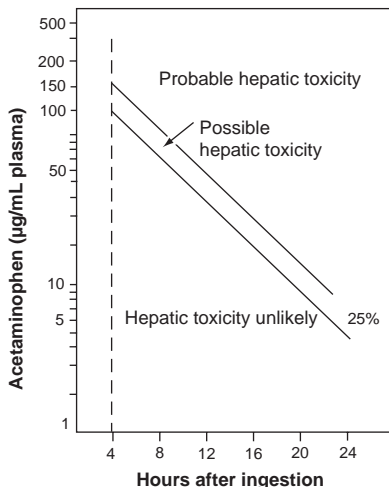
Nomogram relating serum salicylate concentration and expected severity of intoxication at varying levels following the ingestion of a single dose of salicylate. Reproduced with permission from *Pediatrics*, Vol. 62, Pages 890–7, Copyright © 1978 by the AAP.

ASA: Greater Than 50 mg/dL

Signs and symptoms of salicylate intoxication include ketosis, convulsions, dizziness, nausea, vomiting, hyperactivity, hyperglycemia, hyperpnea, hyperthermia, respiratory arrest, and tinnitus. Possible interventions

include administration of activated charcoal as vomiting ceases, alkalization of the urine with bicarbonate, and a single dose of vitamin K (for rare instances of hypoprothrombinemia). (See figure below.)

Acetaminophen Toxicity Nomogram



The Rumack-Matthew nomogram, relating expected severity of liver toxicity to serum acetaminophen concentrations. Reprinted from *Ann Emerg Med*, 20, Smilkstein MJ, Bronstein AC, Linden C, et al, "Acetaminophen Overdose: A 48-Hour Intravenous N-acetylcysteine treatment protocol," 1058, 1991, with permission from Elsevier.

INTERFERING FACTORS:

- Blood drawn in serum separator tubes (gel tubes).
- Contraindicated in patients with liver disease, and caution advised in patients with renal impairment.
- Drugs that may increase acetaminophen levels include diflunisal, metoclopramide, and probenecid.
- Drugs that may decrease acetaminophen levels include carbamazepine, cholestyramine, iron, oral contraceptives, and propantheline.
- Drugs that increase ASA levels include choline magnesium

trisalicylate, cimetidine, furosemide, and sulfipyrazone.

- Drugs and substances that decrease ASA levels include activated charcoal, antacids (aluminum hydroxide), corticosteroids, and iron.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to monitor therapeutic levels and detect toxic levels of acetaminophen and salicylate.
- ♦ Obtain a complete history of the time and amount of drug ingested by the patient.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Review results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the

patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection, noting the last dose of medication taken. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop the bleeding. Observe the venipuncture site for bleeding and hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ *Nutritional considerations* include the avoidance of alcohol consumption.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to

another HCP. Explain to the patient the importance of following the medication regimen and instructions regarding food and drug interactions. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Instruct the patient to be prepared to provide the pharmacist with a list of other medications he or she is already taking in the event that the requesting HCP prescribes a medication.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, AST, bilirubin, biopsy liver, BUN, complete blood count, creatinine, electrolytes, glucose, lactic acid, aPTT, and PT/INR.
- ▶ See the Genitourinary and Hepatobiliary System tables in the back of the book for related tests by body system.

Angiography, Abdomen

SYNONYM/ACRONYM: Abdominal angiogram, abdominal arteriography

AREA OF APPLICATION: Abdomen.

CONTRAST: Intravenous iodine based.

DESCRIPTION: Angiography allows x-ray visualization of the large and small arteries, veins, and associated branches of the abdominal vasculature and organ

parenchyma after contrast medium injection. This visualization is accomplished by the injection of contrast medium through a catheter, which most commonly

has been inserted into the femoral artery and advanced through the iliac artery and aorta into the organ-specific artery. Images of the organ under study and associated vessels are displayed on a monitor and recorded or stored electronically for future viewing and evaluation. Patterns of circulation, organ function, and changes in vessel wall appearance can be viewed to help diagnose the presence of vascular abnormalities, aneurysm, tumor, trauma, or lesions. The catheter used to administer the contrast medium to confirm the diagnosis of organ lesions may be used to deliver chemotherapeutic drugs or different types of materials used to stop bleeding. Catheters with attached inflatable balloons and wire mesh stents are used to widen areas of stenosis and to keep vessels open, frequently replacing surgery. Angiography is one of the definitive tests for organ disease and may be used to evaluate chronic disease and organ failure, treat arterial stenosis, differentiate a vascular cyst from hypervascular cancers, and evaluate the effectiveness of medical or surgical treatment.

INDICATIONS:

- Aid in angioplasty, atherectomy, or stent placement
- Allow infusion of thrombolytic drugs into an occluded artery
- Detect arterial occlusion, which may be evidenced by a transection of the artery caused by trauma or penetrating injury
- Detect artery stenosis, evidenced by vessel dilation, collateral vessels, or increased vascular pressure
- Detect nonmalignant tumors before surgical resection
- Detect tumors and arterial supply, extent of venous invasion, and tumor vascularity
- Detect thrombosis, arteriovenous fistula, aneurysms, or emboli in abdominal vessels
- Differentiate between tumors and cysts
- Evaluate organ transplantation for function or organ rejection
- Evaluate placement of a shunt or stent
- Evaluate tumor vascularity before surgery or embolization
- Evaluate the vascular system of prospective organ donors before surgery

RESULT:

Normal findings in:

- Normal structure, function, and patency of abdominal organ vessels
- Contrast medium normally circulates throughout abdomen symmetrically and without interruption
- No evidence of obstruction, variations in number and size of vessels, malformations, cysts, or tumors

Abnormal findings in:

- Abscess or inflammation
- Arterial aneurysm
- Arterial stenosis, dysplasia, or organ infarction
- Arteriovenous fistula or other abnormalities
- Congenital anomalies
- Cysts or tumors
- Trauma causing tears or other disruption

CRITICAL VALUES:

- Abscess
- Aneurysm

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- ◆ Patients with allergies to shellfish or iodinated contrast medium. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to contrast medium may benefit from pre-medication with corticosteroids or the use of nonionic contrast medium.
- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risk of radiation exposure to the fetus.
- ◆ Elderly and compromised patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
- ◆ Patients who are in renal failure.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and can produce unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a HCP should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.

- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure assesses cardiovascular function.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ◆ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed since contrast medium is to be used.
- ◆ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium or barium. Ensure that barium studies were performed more than 4 days before angiography.
- ◆ Record the date of the last menstrual period and determine the possibility

of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a radiology or vascular suite by a HCP and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually normal saline is infused.
- ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ Instruct the patient to fast and restrict fluids for 2 to 4 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.

▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary and fluid restrictions for 2 to 4 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and assess neurologic status. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish a baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Using a pen, mark the site of the patient's peripheral pulses before angiography; this allows for quicker and more consistent assessment of the pulses after the procedure.
- ▶ Place the patient in the supine position on an exam table. Cleanse the

selected area, and cover with a sterile drape.

- ▶ A local anesthetic is injected at the site, and a small incision is made or a needle inserted under fluoroscopy.
- ▶ The contrast medium is injected, and a rapid series of images is taken during and after the filling of the vessels to be examined. Delayed images may be taken to examine the vessels after a time and to monitor the venous phase of the procedure.
- ▶ Instruct the patient to inhale deeply and hold his or her breathe while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, or activity, as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.

- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Assess extremities for signs of ischemia or absence of distal pulse caused by a catheter-induced thrombus.
- ▶ Instruct the patient in the care and assessment of the site and to observe for bleeding, hematoma formation, bile leakage, and inflammation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography renal, BUN, CT abdomen, CT angiography, CT brain, CT spleen, CT thoracic, creatinine, KUB, MRA, MRI abdomen, MRI brain, MRI chest, MRI pelvis, aPTT, PT/INR, renogram, and US lower extremity.
- ▶ See the Cardiovascular System table at the back of the book for related tests by body system.

Angiography, Adrenal

SYNONYM/ACRONYM: Adrenal angiogram, adrenal arteriography.

AREA OF APPLICATION: Adrenal gland.

CONTRAST: Intravenous iodine based.

DESCRIPTION: Adrenal angiography evaluates adrenal dysfunction by allowing x-ray visualization of the large and small arteries of the adrenal gland vasculature and parenchyma. This visualization is accomplished by the injection of contrast medium through a catheter that has been inserted into the femoral artery for viewing the artery (arteriography) or into the femoral vein for viewing the veins (venography). After the catheter is in place, a blood sample may be taken from the vein of each gland to assess cortisol levels in determining a diagnosis of Cushing's syndrome or the presence of pheochromocytoma. After injection of the contrast medium through the catheter, images of the adrenal glands and associated vessels surrounding the adrenal tissue are displayed on a monitor and are recorded on film or electronically. Patterns of circulation, adrenal function, and changes in vessel wall appearance can be viewed to help diagnose the presence of vascular abnormalities, trauma, or lesions. This definitive test for adrenal disease may be used to evaluate chronic adrenal disease, evaluate arterial or venous stenosis, differentiate an adrenal cyst from adrenal tumors, and evaluate medical therapy or surgery of the adrenal glands.

INDICATIONS:

- Assist in the infusion of thrombolytic drugs into an occluded artery
- Assist with the collection of blood samples from the vein for laboratory analysis
- Detect adrenal hyperplasia
- Detect and determine the location of adrenal tumors evidenced by arterial supply, extent of venous invasion, and tumor vascularity
- Detect arterial occlusion, evidenced by a transection of the artery caused by trauma or a penetrating injury
- Detect arterial stenosis, evidenced by vessel dilation, collateral vessels, or increased vascular pressure
- Detect nonmalignant tumors before surgical resection
- Detect thrombosis, arteriovenous fistula, aneurysms, or emboli in vessels
- Differentiate between adrenal tumors and adrenal cysts
- Evaluate tumor vascularity before surgery or embolization
- Perform angioplasty, perform atherectomy, or place a stent

RESULT:

Normal findings in:

- Normal structure, function, and patency of adrenal vessels
- Contrast medium circulating throughout the adrenal gland symmetrically and without interruption
- No evidence of obstruction, variations in number and size of vessels and organs, malformations, cysts, or tumors




Abnormal findings in:

- Adrenal adenoma
- Adrenal carcinoma
- Bilateral adrenal hyperplasia
- Pheochromocytoma

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiologic procedure
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and can produce unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation over-exposure can result from frequent x-ray procedures. Personnel in the examination room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure assesses adrenal gland function.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens (especially allergies or sensitivities to latex, iodine, seafood, anesthetics or contrast medium).
- ◆ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ◆ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium or barium. Ensure that barium studies were performed more than 4 days before angiography.
- ◆ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Record the date of the last menstrual period and determine the possibility

of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a radiology or vascular suite by a HCP and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually normal saline is infused.
- ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 2 to 4 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.
- ▶ *Make sure a written and informed consent has been signed prior to the*

procedure and before administering any medications.

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluid, and medication restrictions and pretesting preparations.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish a baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Using a pen, mark the site of the patient's peripheral pulses before angiography; this allows for quicker and more consistent assessment of the pulses after the procedure.
- ▶ Place the patient in the supine position on an exam table. Cleanse

the selected area, and cover with a sterile drape.

- ▶ A local anesthetic is injected at the site, and a small incision is made or a needle inserted under fluoroscopy.
- ▶ The contrast medium is injected, and a rapid series of images is taken during and after the filling of the vessels to be examined. Delayed images may be taken to examine the vessels after a time and to monitor the venous phase of the procedure.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, or activity, as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Assess extremities for signs of ischemia or absence of distal pulse

caused by a catheter-induced thrombus.

- ▶ Instruct the patient in the care and assessment of the site and to observe for bleeding, hematoma formation, bile leakage and inflammation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include adrenal gland scan, ACTH and challenge tests, catecholamines, cortisol and challenge tests, CT abdomen, creatinine, BUN, glucose tolerance tests, HVA, KUB study, MRI abdomen, metanephrines, aPTT, PT/INR, renin, and VMA.
- ▶ Refer to the Endocrine System table in the back of the book for related tests by body system.

Angiography, Carotid

SYNONYM/ACRONYM: Carotid angiogram, carotid arteriography.

AREA OF APPLICATION: Neck/cervical area.

CONTRAST: Intravenous iodine based.

DESCRIPTION: The test evaluates blood vessels in the neck carrying arterial blood. This visualization is accomplished by the injection of contrast material through a catheter that has been inserted into the femoral artery for viewing the artery (arteriography). The angiographic catheter is a long tube about the size of a strand of spaghetti. After the injection of contrast media through the catheter, x-ray images of the carotid artery and associated vessels in surrounding tissue are displayed on a monitor and are recorded on film or electronically. The x-ray equipment is mounted on a C-shaped bed with the x-ray device beneath the table on which the patient lies. Over the patient is an image intensifier that receives the x-rays after they pass through the patient. Patterns of circulation or changes in vessel wall appearance can be viewed to help diagnose the presence of vascular abnormalities, disease, narrowing, enlargement, blockage, trauma, or lesions. This definitive test for arterial disease may be used to evaluate chronic vascular disease, arterial or venous stenosis, and medical therapy or surgery of the vasculature. Catheter angiography still is used in patients who may undergo surgery, angioplasty, or stent placement.

INDICATIONS:

- Aid in angioplasty, atherectomy, or stent placement
- Allow infusion of thrombolytic drugs into an occluded artery
- Detect arterial occlusion, which may be evidenced by a transection of the artery caused by trauma or penetrating injury
- Detect artery stenosis, evidenced by vessel dilation, collateral vessels, or increased vascular pressure
- Detect nonmalignant tumors before surgical resection
- Detect tumors and arterial supply, extent of venous invasion, and tumor vascularity
- Detect thrombosis, arteriovenous fistula, aneurysms, or emboli in vessels
- Evaluate placement of a stent
- Differentiate between tumors and cysts
- Evaluate tumor vascularity before surgery or embolization
- Evaluate the vascular system of prospective organ donors before surgery

RESULT:

Normal finding in:

- Normal structure, function and patency of carotid arteries
- Contrast medium normally circulates throughout neck symmetrically and without interruption
- No evidence of obstruction, variations in number and size of vessels, malformations, cysts, or tumors




Abnormal findings in:

- Abscess or inflammation
- Arterial aneurysm
- Arterial stenosis or dysplasia
- Aneurysms
- Arteriovenous fistula or other abnormalities
- Congenital anomalies
- Cysts or tumors
- Trauma causing tears or other disruption
- Vascular blockage or other disruption

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated contrast medium. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risk of radiation exposure to the fetus.
-  Elderly and compromised patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiologic procedure
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ

visualization and can produce unclear images

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses cardiovascular function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed since contrast medium is to be used.

- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium or barium. Ensure that barium studies were performed more than 4 days before angiography.
 - ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
 - ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
 - ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
 - ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a radiology or vascular suite by a HCP and takes approximately 30 to 60 min.
 - ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
 - ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually normal saline is infused.
 - ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
 - ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
 - ▶ Instruct the patient to fast and restrict fluids for 2 to 4 hr prior to the procedure. Protocols may vary from facility to facility.
 - ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.
 - ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- INTRATEST:**
- ▶ Ensure the patient has complied with dietary, fluid, and medication restrictions and pretesting preparations.
 - ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
 - ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
 - ▶ Have emergency equipment readily available.
 - ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
 - ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
 - ▶ Record baseline vital signs, and assess neurologic status. Protocols may vary from facility to facility.
 - ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
 - ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
 - ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
 - ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish a baseline rhythm; determine if the patient has ventricular arrhythmias.
 - ▶ Using a pen, mark the site of the patient's peripheral pulses before angiography; this allows for quicker

and more consistent assessment of the pulses after the procedure.

- ▶ Place the patient in the supine position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ▶ A local anesthetic is injected at the site, and a small incision is made or a needle inserted under fluoroscopy.
- ▶ The contrast medium is injected, and a rapid series of images is taken during and after the filling of the vessels to be examined. Delayed images may be taken to examine the vessels after a time and to monitor the venous phase of the procedure.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, or activity, as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.

- ▶ Assess extremities for signs of ischemia or absence of distal pulse caused by a catheter-induced thrombus.
- ▶ Instruct the patient in the care and assessment of the site and to observe for bleeding, hematoma formation, bile leakage, and inflammation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography abdomen, BUN, CT angiography, CT brain, creatinine, blood, ECG, exercise stress test, MRA, MRI brain, PT/INR, plethysmography, US arterial doppler lower extremities, and US peripheral doppler.
- ▶ See the Cardiovascular System table at the back of the book for related tests by body system.

Angiography, Coronary

SYNONYM/ACRONYM: Angiocardiography, cardiac angiography, cardiac catheterization, cineangiography, coronary arteriography.

AREA OF APPLICATION: Heart

CONTRAST: Intravenous iodine based.

DESCRIPTION: Angiography allows x-ray visualization of the heart, aorta, inferior vena cava, pulmonary artery and vein, and coronary arteries after injection of contrast medium. Contrast medium is injected through a catheter, which has been inserted into a peripheral vein for a right heart catheterization or an artery for a left heart catheterization; through the same catheter, cardiac pressures are recorded. Images of the heart and associated vessels are displayed on a monitor and are recorded on film or electronically. Patterns of circulation, cardiac output, cardiac functions, and changes in vessel wall appearance can be viewed to help diagnose the presence of vascular abnormalities or lesions. Pulmonary artery abnormalities are seen with right heart views, and coronary artery and thoracic aorta abnormalities are seen with left heart views. Coronary angiography is a definitive test for coronary artery disease, and it is useful for evaluating other types of cardiac abnormalities.

INDICATIONS:

- Allow infusion of thrombolytic drugs into an occluded coronary
- Detect narrowing of coronary vessels or abnormalities of the great vessels in patients with angina,

syncope, abnormal electrocardiogram, hypercholesteremia with chest pain, and persistent chest pain after revascularization

- Evaluate cardiac muscle function
- Evaluate cardiac valvular and septal defects
- Evaluate disease associated with the aortic arch
- Evaluate previous cardiac surgery or other interventional procedures
- Evaluate ventricular aneurysms
- Monitor pulmonary pressures and cardiac output
- Perform angioplasty, perform atherectomy, or place a stent
- Quantify the severity of atherosclerotic, occlusive coronary artery disease

RESULT:

Normal findings in:

- Normal great vessels and coronary arteries

Abnormal findings in:




- Aortic atherosclerosis
- Aortic dissection
- Aortitis
- Aneurysms
- Cardiomyopathy
- Congenital anomalies
- Coronary artery atherosclerosis and degree of obstruction
- Graft occlusion
- Pulmonary artery abnormalities
- Septal defects
- Trauma causing tears or other disruption
- Tumors
- Valvular disease

CRITICAL VALUES:

- Aneurysm
- Aortic dissection

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

-  Patients with allergies to shellfish or iodinated contrast medium. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risk of radiation exposure to the fetus.
-  Elderly and compromised patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiologic procedure
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and can produce unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses cardiovascular function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergies (especially allergies or sensitivities to latex, iodine, seafood, anesthetics or contrast medium).
- ▶ Obtain a history of results of the patient's cardiovascular and respiratory system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium or barium. Ensure that barium studies were performed more than 4 days before angiography.
- ▶ Record the date of last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin dependent (type 2) diabetes should be instructed as ordered to discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a radiology or vascular suite by a HCP and takes approximately 30–60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives. Usually normal saline is infused.
- ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ Instruct the patient to fast and restrict fluids for 2 to 4 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.
- ▶ *Make sure a written and informed consent has been signed prior to the*

procedure and before administering any medications.

INTRATEST:

- ▶ Ensure the patient has complied with dietary and fluid restrictions for 2 to 4 hr prior to the procedure.
- ▶ Ensure that the patient has removed external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an anti-anxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish a baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Using a pen, mark the site of the patient's peripheral pulses before angiography; this allows for quicker and more consistent assessment of the pulses after the procedure.
- ▶ Place the patient in the supine position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ▶ A local anesthetic is injected at the site, and a small incision is made or a needle inserted under fluoroscopy.
- ▶ The contrast medium is injected, and a rapid series of images is taken during

and after the filling of the vessels to be examined. Delayed images may be taken to examine the vessels after a time and to monitor the venous phase of the procedure.

- ▶ Ask the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Take temperature every 4 hr for 24 hr. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Assess extremities for signs of ischemia or absence of distal pulse caused by a catheter-induced thrombus.
- ▶ Instruct the patient in the care and assessment of the site and to observe for bleeding, hematoma formation, bile leakage, and inflammation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ▶ Instruct the patient to apply cold compresses to the puncture site as

needed, to reduce discomfort or edema.

- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
- ▶ *Nutritional considerations:* A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography carotid, blood pool imaging, BNP, BUN, chest x-ray, CT abdomen, CT angiography, CT biliary tract and liver, CT cardiac scoring, CT spleen, CT thoracic, CK, creatinine, CRP, electrocardiography, electrocardiography transesophageal, Holter monitor, homocysteine, MR angiography, MRI abdomen, MRI chest, myocardial perfusion heart scan, plethysmography, aPTT, PT/INR, troponin, and US arterial doppler carotid.
- ▶ Refer to the Cardiovascular and Respiratory System tables at the back of the book for related tests by body system.

Angiography, Pulmonary

SYNONYM/ACRONYM: Pulmonary angiography, pulmonary arteriography.

AREA OF APPLICATION: Pulmonary vasculature.

CONTRAST: Intravenous iodine based.

DESCRIPTION: Pulmonary angiography allows x-ray visualization of the pulmonary vasculature after injection of an iodinated contrast medium into the pulmonary artery or a branch of this great vessel. Contrast medium is injected through a catheter that has been inserted into the vascular system, usually through the femoral vein. It is one of the definitive tests for pulmonary embolism, but it is also useful for evaluating other types of pulmonary vascular abnormalities. It is definitive for peripheral pulmonary artery stenosis, anomalous pulmonary venous drainage, and pulmonary fistulae. Hemodynamic measurements during pulmonary angiography can assist in the diagnosis of pulmonary hypertension and cor pulmonale.

INDICATIONS:

- Detect acute pulmonary embolism
- Detect arteriovenous malformations or aneurysms
- Detect tumors; aneurysms; congenital defects; vascular changes associated with emphysema, blebs, and bullae; and heart abnormalities

- Determine the cause of recurrent or severe hemoptysis
- Evaluate pulmonary circulation

RESULT:

Normal findings in:

- Normal pulmonary vasculature; radiopaque iodine contrast medium should circulate symmetrically and without interruption through the pulmonary circulatory system.

Abnormal findings in:

- Aneurysms
- Arterial hypoplasia or stenosis
- Arteriovenous malformations
- Bleeding caused by tuberculosis, bronchiectasis, sarcoidosis, or aspergilloma
- Inflammatory diseases
- Pulmonary embolism (PE) acute or chronic
- Pulmonary sequestration
- Tumors


CRITICAL VALUES:

- PE



Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated contrast medium. The contrast medium

used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.

- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.

Factors that may impair clear imaging:

- Retained barium from a previous radiologic procedure
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and can produce unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses cardiovascular function.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ♦ Obtain a history of the patient's cardiovascular and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ♦ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium or barium. Ensure that barium studies were performed more than 4 days before angiography.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.

- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a radiology or vascular suite by a HCP and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives. Usually normal saline is infused.
- ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ Instruct the patient to fast and restrict fluids for 2 to 4 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish a baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Using a pen, mark the site of the patient's peripheral pulses before angiography; this allows for quicker and more consistent assessment of the pulses after the procedure.
- ▶ Place the patient in the supine position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ▶ A local anesthetic is injected at the site, and a small incision is made or a needle inserted under fluoroscopy.
- ▶ The contrast medium is injected, and a rapid series of images is taken during

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluid and medication restrictions and pretesting preparations for 2 to 4 hr prior to the procedure.

and after the filling of the vessels to be examined.

- ▶ Instruct the patient to inhale deeply and hold his or her breath while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, or activity, as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take the temperature every 4 hr for 24 hr. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Assess extremities for signs of ischemia or absence of distal pulse caused by a catheter-induced thrombus.
- ▶ Instruct the patient in the care and assessment of the site and to observe

for bleeding, hematoma formation, bile leakage, and inflammation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.

- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include alveolar/arterial gradient, blood gases, BUN, chest x-ray, creatinine, CT angiography, CT thoracic, ECG, FDP, lactic acid, lung perfusion scan, lung ventilation scan, MRA, MRI chest, aPTT, and PT/INR.
- ▶ Refer to the Cardiovascular and Respiratory System tables at the back of the book for related tests by body system.

Angiography, Renal

SYNONYM/ACRONYM: Renal angiogram, renal arteriography.

AREA OF APPLICATION: Kidney.

CONTRAST: Intravenous iodine based.

DESCRIPTION: Renal angiography allows x-ray visualization of the large and small arteries of the renal vasculature and parenchyma or the renal veins and their branches. Contrast medium is injected through a catheter that has been inserted into the femoral artery or vein and advanced through the iliac artery and aorta into the renal artery or the inferior vena cava into the renal vein. Images of the kidneys and associated vessels are displayed on a monitor and recorded on film or electronically. Patterns of circulation, renal function, or changes in vessel wall appearance can be viewed to help diagnose the presence of vascular abnormalities, trauma, or lesions. This definitive test for renal disease may be used to evaluate chronic renal disease, renal failure, and renal artery stenosis; differentiate a vascular renal cyst from hypervascular renal cancers; and evaluate renal transplant donors, recipients, and the kidney after transplantation.

INDICATIONS:

- Aid in angioplasty, atherectomy, or stent placement
- Allow infusion of thrombolytic drugs into an occluded artery

- Assist with the collection of blood samples from renal vein for renin analysis
- Detect arterial occlusion as evidenced by a transection of the renal artery caused by trauma or a penetrating injury
- Detect nonmalignant tumors before surgical resection
- Detect renal artery stenosis as evidenced by vessel dilation, collateral vessels, or increased renovascular pressure
- Detect renal tumors as evidenced by arterial supply, extent of venous invasion, and tumor vascularity
- Detect small kidney or absence of a kidney
- Detect thrombosis, arteriovenous fistulae, aneurysms, or emboli in renal vessels
- Differentiate between renal tumors and renal cysts
- Evaluate placement of a stent
- Evaluate postoperative renal transplantation for function or organ rejection
- Evaluate renal function in chronic renal failure or end-stage renal disease or hydronephrosis
- Evaluate the renal vascular system of prospective kidney donors before surgery
- Evaluate tumor vascularity before surgery or embolization

RESULT:

Normal finding in:

- Normal structure, function, and patency of renal vessels

- Contrast medium circulating throughout the kidneys symmetrically and without interruption
- No evidence of obstruction, variations in number and size of vessels and organs, malformations, cysts, or tumors




Abnormal findings in:

- Abscess or inflammation
- Arterial stenosis, dysplasia, or infarction
- Arteriovenous fistula or other abnormalities
- Congenital anomalies
- Intrarenal hematoma
- Renal artery aneurysm
- Renal cysts or tumors
- Trauma causing tears or other disruption

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated contrast medium. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiologic procedure
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and can produce unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses vascular and urinary function.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens (especially allergies or sensitivities to latex, iodine, seafood, anesthetics or contrast medium).
 - ▶ Obtain a history of the patient's genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed since contrast medium is to be used.
 - ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium or barium. Ensure that barium studies were performed more than 4 days before angiography.
 - ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
 - ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
 - ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
 - ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a radiology or vascular suite by a HCP and takes approximately 30 to 60 min.
 - ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
 - ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives. Usually normal saline is infused.
 - ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
 - ▶ Instruct the patient to remove jewelry, and other metallic objects from the area to be examined.
 - ▶ Instruct the patient to fast and restrict fluids for 2 to 4 hr prior to the procedure. Protocols may vary from facility to facility.
 - ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.
 - ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- INTRATEST:**
- ▶ Ensure the patient has complied with dietary, fluid, and medication restrictions for 2 to 4 hr prior to the procedure.
 - ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
 - ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use non-ionic contrast medium for the procedure.
 - ▶ Have emergency equipment readily available.
 - ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
 - ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because

movement produces unreliable results.

- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish a baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Using a pen, mark the site of the patient's peripheral pulses before angiography; this allows for quicker and more consistent assessment of the pulses after the procedure.
- ▶ Place the patient in the supine position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ▶ A local anesthetic is injected at the site, and a small incision is made or a needle inserted under fluoroscopy.
- ▶ The contrast medium is injected, and a rapid series of images is taken during and after the filling of the vessels to be examined. Delayed images may be taken to examine the vessels after a time and to monitor the venous phase of the procedure.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

- ▶ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Assess extremities for signs of ischemia or absence of distal pulse caused by a catheter-induced thrombus.
- ▶ Instruct the patient in the care and assessment of the site and to observe for bleeding, hematoma formation, bile leakage, and inflammation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.

- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review

corresponding literature provided by a pharmacist.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy kidney, BUN, creatinine, CT abdomen, CT angiography, culture urine, cytology urine, KUB study, IVP, MRA, MRI abdomen, aPTT, PT/INR, renin, renogram, US kidney, and UA.
- ▶ Refer to the Genitourinary System table at the back of the book for related tests by body system.

Angiotensin-Converting Enzyme

SYNONYM/ACRONYM: Angiotensin I-converting enzyme (ACE).

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 0.017)
0–2 yr	5–83 units/L	0.09–1.41 microKat/L
3–7 yr	8–76 units/L	0.14–1.29 microKat/L
8–14 yr	6–89 units/L	0.10–1.51 microKat/L
Greater than 14 yr	8–52 units/L	0.14–0.88 microKat/L

RESULT:

Increased in:

- Bronchitis (acute and chronic)
(*damage to pulmonary tissue releases ACE*)

- Connective tissue disease
- Gaucher's disease
- Hansen's disease (leprosy)
- Histoplasmosis and other fungal diseases

- Hyperthyroidism (untreated) (*thyroid hormones are thought to be involved in regulation of ACE*)
- Pulmonary fibrosis (*damage to pulmonary tissue releases ACE*)
- Rheumatoid arthritis
- Sarcoidosis (*damage to pulmonary tissue releases ACE*)

Decreased in:

- Advanced pulmonary carcinoma (*lack of functional cells to produce ACE*)
- The period following corticosteroid therapy for sarcoidosis

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Anion Gap

SYNONYM/ACRONYM: Agap.

SPECIMEN: Serum (1 mL) for electrolytes collected in a red- or tiger-top tube. Plasma (1 mL) collected in a green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Anion gap is derived mathematically from the direct measurement of sodium, chloride, and total carbon dioxide.) There are differences between serum and plasma values for some electrolytes. The reference ranges listed are based on serum values.

Age	Conventional Units	SI Units (Conventional Units × 1)
Child	8–16 mEq/L	8–16 mmol/L
Adult	8–16 mEq/L	8–16 mmol/L

DESCRIPTION: The anion gap is used most frequently as a clinical indicator of metabolic acidosis. The most common causes of an increased gap are lactic acidosis and ketoacidosis. The concept of estimating electrolyte disturbances in the extracellular fluid is based on the principle of electrical neutrality. The formula includes the major cation (sodium) and anions

(chloride and bicarbonate) found in extracellular fluid. The anion gap is calculated as follows:

$$\text{anion gap} = \text{sodium} - (\text{chloride} + \text{HCO}_3^-)$$

Because bicarbonate (HCO_3^-) is not directly measured on most chemistry analyzers, it is estimated by substitution of the total carbon dioxide (TCO_2) value in the calculation. Some

laboratories may include potassium in the calculation of the anion gap. Calculations including potassium can be invalidated because minor amounts of hemolysis can contribute significant levels of potassium leaked into the serum as a result of cell rupture. The anion gap is also widely used as a laboratory quality control measure because low gaps usually indicate a reagent, calibration, or instrument error.

INDICATIONS:

- Evaluate metabolic acidosis
- Indicate the presence of a disturbance in electrolyte balance
- Indicate the need for laboratory instrument recalibration or review of electrolyte reagent preparation and stability

RESULT:

Increased in:

- **(Metabolic acidosis that results from the accumulation of unmeasured anionic substances like proteins, phosphorus, sulfates, ketoacids, or other organic acid waste products of metabolism)**
- Dehydration (severe)
- Ketoacidosis **caused by starvation, high-protein/low-carbohydrate diet, diabetes, and alcoholism**
- Lactic acidosis **(shock, excessive exercise, some malignancies)**
- Poisoning (salicylate, methanol, ethylene glycol, or paraldehyde)
- Renal failure
- Uremia

Decreased in:

- **(Conditions that result in metabolic alkalosis)**
- Chronic vomiting or gastric suction **(alkalosis due to net loss of acid)**
- Excess alkali ingestion
- Hypergammaglobulinemia **(cationic unmeasured M proteins excessively produced in multiple myeloma cause an increase in measured anions)**
- Hypoalbuminemia **(decreased levels of unmeasured anionic proteins relative to unchanged cation concentration)**
- Hyponatremia **(net loss of cations)**

Significant acidosis or alkalosis can result from increased levels of unmeasured cations like ionized calcium and magnesium or unmeasured anions like proteins, phosphorus, sulfates or other organic acids, the effects of which may not be accurately reflected by the calculated anion gap.

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that can increase or decrease the anion gap include those listed in the individual electrolyte (i.e., sodium, chloride, calcium, magnesium, and total carbon dioxide), total protein, lactic acid, and phosphorus monographs.
- Specimens should never be collected above an intravenous line because of the potential for dilution when the specimen and the intravenous solution combine in the collection container, falsely decreasing the result. There is also the potential of contaminating the sample with the substance of interest, if it is

present in the intravenous solution, falsely increasing the result.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the evaluation of electrolyte balance.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, endocrine, gastrointestinal, genitourinary, hematopoietic, immune, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding and hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations*: Specific dietary considerations are listed in the monographs on individual electrolytes (i.e., sodium, chloride, calcium, magnesium, and potassium), total protein, and phosphorus.
- ▶ *Nutritional considerations*: The anion gap can be used to indicate the presence of dehydration. Evaluate the patient for signs and symptoms of dehydration. Dehydration is a significant and common finding in geriatric patients.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include albumin, blood gases, BUN, creatinine, electrolytes, ethanol (drugs of abuse), glucose, ketones, lactic acid, osmolality, protein and fractions, salicylate, and UA.

See the Cardiovascular, Endocrine, Gastrointestinal, Genitourinary, Hematopoietic, Immune, and Respiratory System tables in the back of the book for related tests by body system.

A

Antiarrhythmic Drugs: Digoxin, Disopyramide, Flecainide, Lidocaine, Procainamide, Quinidine

SYNONYM/ACRONYM: *Digoxin* (Digitek, Lanoxicaps, Lanoxin); *disopyramide* (Norpace, Norpace CR); *flecainide* (flecainide acetate, Tambacor); *lidocaine* (Xylocaine); *procainamide* (Procanbid, Pronestyl, Pronestyl SR); *quinidine* (Quinidex Extentabs, quinidine sulfate SR, quinidine gluconate SR).

SPECIMEN: Serum (1 mL) collected in a red-top tube.

Drug	Route of Administration	Recommended Collection Time
Digoxin	Oral	Trough: 12–24 hr after dose Never draw peak samples
Disopyramide	Oral	Trough: immediately before next dose Peak: 2–5 hr after dose
Flecainide	Oral	Trough: immediately before next dose Peak: 3 hr after dose
Lidocaine	IV	15 min, 1 hr, then every 24 hr
Procainamide	IV	15 min; 2, 6, 12 hr; then every 24 hr
Procainamide	Oral	Trough: immediately before next dose Peak: 75 min after dose
Quinidine sulfate	Oral	Trough: immediately before next dose Peak: 1 hr after dose
Quinidine gluconate	Oral	Trough: immediately before next dose Peak: 5 hr after dose
Quinidine polygalacturonate	Oral	Trough: immediately before next dose Peak: 2 hr after dose

REFERENCE VALUE: (Method: Immunoassay)

Drug (Indication)	Therapeutic Dose*	SI Units	Half-Life (hr)	Volume of Distribution (L/kg)	Protein Binding (%)	Excretion
(SI = Conventional Units X 1.28) Digoxin	0.5–2.0 ng/mL	0.6–2.6 nmol/L	20–60	7	20–30	1° renal
(SI = Conventional Units X 2.95) Disopyramide (atrial arrhythmias)	2.8–3.2 mcg/mL	8.3–9.4 micromol/L	4–10	0.7–0.9	20–60	1° renal
Disopyramide (ventricular arrhythmias)	3.3–5.0 mcg/mL	9.7–15.0 micromol/L				1° renal
(SI = Conventional Units X 2.41) Flecainide	0.2–1.0 mcg/mL	0.5–2.4 micromol/L	7–19	5–13	40–50	1° renal
(SI = Conventional Units X 4.27) Lidocaine	1.5–5.0 mcg/mL	6.4–21.4 micromol/L	1.5–2	1–1.5	60–80	1° hepatic
(SI = Conventional Units X 4.23) Procainamide	4–10 mcg/mL	17–42 micromol/L	2–6	2–4	10–20	1° renal
(SI = Conventional Units X 3.61) Procainamide + N-acetyl procainamide	10–30 mcg/mL	36–108 micromol/L	8			1° renal
(SI = Conventional Units X 3.08) Quinidine	2–5 mcg/mL	6–15 micromol/L	6–8	2–3	70–90	Renal and hepatic

*Conventional units.

DESCRIPTION: Cardiac glycosides are used in the prophylactic management and treatment of heart failure and ventricular and atrial arrhythmias. Because these drugs have narrow therapeutic windows, they must be monitored closely. The signs and symptoms of toxicity are often difficult to distinguish from those of cardiac disease. Patients with toxic levels may show gastrointestinal, ocular, and central nervous system effects and disturbances in potassium balance.

Many factors must be considered in effective dosing and monitoring of therapeutic drugs, including patient age, patient weight, interacting medications, electrolyte balance, protein levels, water balance, conditions that affect absorption and excretion, and the ingestion of substances (e.g., foods, herbals, vitamins, and minerals) that can either potentiate or inhibit the intended target concentration.

Peak and trough collection times should be documented carefully in relation to the time of medication administration.

IMPORTANT NOTE: This information must be communicated clearly and accurately to avoid misunderstanding of the dose time in relation to the collection time. Miscommunication between the individual administering the medication and the individual collecting the specimen is the most frequent cause of subtherapeutic levels, toxic levels, and misleading information used in the calculation of future doses.

INDICATIONS:


- Assist in the diagnosis and prevention of toxicity
- Monitor compliance with therapeutic regimen
- Monitor patients who have a pacemaker, who have impaired renal or hepatic function, or who are taking interacting drugs

RESULT:

Level	Result
Normal levels	Therapeutic effect
Subtherapeutic levels	Adjust dose as indicated
Toxic levels	Adjust dose as indicated
<i>Digoxin</i>	Renal impairment, CHF*, elderly patients
<i>Disopyramide</i>	Renal impairment
<i>Flecainide</i>	Renal impairment, CHF
<i>Lidocaine</i>	Hepatic impairment, CHF
<i>Procainamide</i>	Renal impairment
<i>Quinidine</i>	Renal and hepatic impairment, CHF, elderly patients

*CHF = congestive heart failure.

CRITICAL VALUES:

-  Adverse effects of subtherapeutic levels are

important. Care should be taken to investigate the signs and symptoms of too little and too much

medication. Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms.

Digoxin: Greater Than 2.5 ng/mL

Signs and symptoms of digoxin toxicity include arrhythmias, anorexia, hyperkalemia, nausea, vomiting, diarrhea, changes in mental status, and visual disturbances (objects appear yellow or have halos around them). Possible interventions include discontinuing the medication, continuous electrocardiographic (ECG) monitoring (prolonged P-R interval, widening QRS interval, lengthening Q-Tc interval, and atrioventricular block), transcutaneous pacing, administration of activated charcoal (if the patient has a gag reflex and central nervous system function), support and treatment of electrolyte disturbance, and administration of Digibind (digoxin immune Fab). The amount of Digibind given depends on the level of digoxin to be neutralized. Digoxin levels must be measured before the administration of Digibind. Digoxin levels should not be measured for several days after administration of Digibind in patients with normal renal function (1 wk or longer in patients with decreased renal function). Digibind cross-reacts in the digoxin assay and may provide misleading elevations or decreases in values depending on the particular assay in use by the laboratory.

Disopyramide: Greater Than 7mcg/mL

Signs and symptoms of disopyramide toxicity include prolonged Q-T interval, ventricular tachycardia, hypotension, and heart failure. Possible interventions include discontinuing the medication, airway support, and ECG and blood pressure monitoring.

Flecainide: Greater Than 1 mcg/mL

Signs and symptoms of flecainide toxicity include exaggerated pharma-

cologic effects resulting in arrhythmia. Possible interventions include discontinuing the medication as well as continuous ECG, respiratory, and blood pressure monitoring.

Lidocaine: Greater Than 6 mcg/mL

Signs and symptoms of lidocaine toxicity include slurred speech, central nervous system depression, cardiovascular depression, convulsions, muscle twitches, and possible coma. Possible interventions include continuous ECG monitoring, airway support, seizure precautions, and hourly monitoring of temperature for hyperthermia.

Procainamide: Greater Than 12 mcg/mL; Procainamide + N-acetyl Procainamide: Greater Than 30 mcg/mL

The active metabolite of procainamide is *N*-acetyl procainamide (NAPA). Signs and symptoms of procainamide toxicity include torsade de pointes (ventricular tachycardia), nausea, vomiting, agranulocytosis, and hepatic disturbances. Possible interventions include airway protection, emesis, gastric lavage, and administration of sodium lactate.

Quinidine: Greater Than 8 mcg/mL

Signs and symptoms of quinidine toxicity include ataxia, nausea, vomiting, diarrhea, respiratory system depression, hypotension, syncope, anuria, arrhythmias (heart block, widening of QRS and Q-T intervals), asystole, hallucinations, paresthesia, and irritability. Possible interventions include airway support, emesis, gastric lavage, administration of activated charcoal, administration of sodium lactate, and temporary transcutaneous or transvenous pacemaker.

INTERFERING FACTORS:

- Blood drawn in serum separator tubes (gel tubes).
- Contraindicated in patients with liver disease, and caution

advised in patients with renal impairment.

- Drugs that may increase digoxin levels or increase risk of toxicity include amiodarone, amphotericin B, diclofenac, diltiazem, erythromycin, ibuprofen, indomethacin, nifedipine, nisoldipine, propafenone, propantheline, quinidine, spironolactone, tetracycline, tiapamil, toleanomycin, and verapamil.
- Drugs that may decrease digoxin levels include albuterol, aluminum hydroxide (antacids), carbamazepine, cholestyramine, colestipol, digoxin immune Fab, hydralazine, hydroxychloroquine, iron, kaolin-pectin, magnesium hydroxide, magnesium trisilicate, metoclopramide, neomycin, nitroprusside, paroxetine, phenytoin, rifabutin, sulfasalazine, and ticlopidine.
- Drugs that may increase disopyramide levels or increase risk of toxicity include amiodarone, atenolol, quinidine, ritonavir, and toleanomycin.
- Drugs that may decrease disopyramide levels include phenobarbital, phenytoin, rifabutin, and rifampin.
- Drugs that may increase flecainide levels or increase risk of toxicity include amiodarone and cimetidine.
- Drugs that may decrease flecainide levels include carbamazepine, charcoal, phenobarbital, and phenytoin.
- Drugs that may increase lidocaine levels or increase risk of toxicity include β -blockers, cimetidine, metoprolol, nadolol, propranolol, and ritonavir.
- Drugs that may decrease lidocaine levels include phenytoin.
- Drugs that may increase procainamide levels or increase risk of toxicity include amiodarone, cimetidine, quinidine, ranitidine, and trimethoprim.
- Drugs that may increase quinidine levels or increase risk of toxicity include acetazolamide, amiodarone, cimetidine, itraconazole, mibefradil, nifedipine, nisoldipine, quinidine, ranitidine, thiazide diuretics, and verapamil.
- Drugs that may decrease quinidine levels include disopyramide, kaolin-pectin, ketoconazole, nifedipine, phenobarbital, phenytoin, rifabutin, and rifampin.
- Digitoxin cross-reacts with digoxin; results are falsely elevated if digoxin is measured when the patient is taking digitoxin.
- Digitalis-like immunoreactive substances are found in the serum of some patients who are not taking digoxin, causing false-positive results. Patients whose serum contain digitalis-like immunoreactive substances usually have a condition related to salt and fluid retention, such as renal failure, hepatic failure, low-renin hypertension, and pregnancy.
- Unexpectedly low digoxin levels may be found in patients with thyroid disease.
- Disopyramide may cause a decrease in glucose levels. It may also potentiate the anticoagulating effects of warfarin.
- Long-term administration of procainamide can cause false-positive antinuclear antibody results and development of a lupuslike syndrome in some patients.
- Quinidine may potentiate the effects of neuromuscular blocking medications and warfarin anticoagulants.
- Concomitant administration of quinidine and digoxin can rapidly raise digoxin to toxic levels. If both drugs are to be given together, the digoxin level should be measured before the first dose of quinidine and again in 4 to 6 days.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to monitor for therapeutic and toxic drug levels.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Consider recommended collection time in relation to the

dosing schedule. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection, noting the last dose of medication taken. Perform a venipuncture.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ *Nutritional considerations* include the avoidance of alcohol consumption.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain to the patient the importance of following the medication regimen and instructions regarding drug interactions. Instruct the patient to immediately report any unusual sensations (e.g., dizziness, changes in vision, loss of appetite, nausea, vomiting, diarrhea, weakness, or irregular heartbeat) to his or her HCP. Instruct the patient not to take medicine within 1 hr of food high in fiber. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient to be prepared to provide the pharmacist with a list of other medications he or she is already taking in the event that the requesting HCP prescribes a medication.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Testing for aspirin responsiveness/resistance may be a consideration for patients, especially women, on low-dose aspirin therapy. Evaluate test results in relation to the

patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include ALT, albumin, ALP, apolipoprotein A and B, atrial natriuretic peptide, BNP, blood gases, BUN, CRP, calcium, calcium ionized, cholesterol (total, HDL, and LDL),

CK and isoenzymes, creatinine, glucose, glycated hemoglobin, homocysteine, ketones, LDH and isoenzymes, magnesium, myoglobin, platelet count, potassium, triglycerides, and troponin.

See the Genitourinary and Hepatobiliary System tables in the back of the book for related tests by body system.

Antibiotic Drugs—Aminoglycosides: Amikacin, Gentamicin, Tobramycin; Tricyclic Glycopeptide: Vancomycin

SYNONYM/ACRONYM: *Amikacin* (Amikin); *gentamicin* (Garamycin, Genoptic, Gentacidin, Gentafair, Gentak, Gentamar, Gentrasul, G-myticin, Oco-Mycin, Spectro-Genta); *tobramycin* (Nebcin, Tobrex); *vancomycin* (Lymphocin, Vancocin, Vancoled).

SPECIMEN: Serum (1 mL) collected in a red-top tube.

Antibiotic Type	Route of Administration	Recommended Collection Time*
<i>Aminoglycosides</i>		
<i>Amikacin</i>	IV, IM	Trough: immediately before next dose Peak: 30 min after the end of a 30-min IV infusion
<i>Gentamicin</i>	IV, IM	Trough: immediately before next dose Peak: 30 min after the end of a 30-min IV infusion
<i>Tobramycin</i>	IV, IM	Trough: immediately before next dose Peak: 30 min after the end of a 30-min IV infusion
<i>Tricyclic glycopeptide</i>	IV, PO	Trough: immediately before next dose Peak: 30–60 min after the end of a 60-min IV infusion
<i>Vancomycin</i>		

*Usually after fifth dose if given every 8 hr or third dose if given every 12 hr.
IV = intravenous; IM = intramuscular; PO = by mouth.

REFERENCE VALUE: (Method: Immunoassay)

Drug	Therapeutic Dose*	SI Units	Half-Life (hr)	Distribution (L/kg)	Volume of Binding (%)	Protein Excretion
(SI = Conventional Units X 1.71)						
Amikacin						
Peak	20–30 mcg/mL	34–51 micromol/L	4–8	0.4–1.3	50	1° renal
Trough	1–8 mcg/mL	2–14 micromol/L				
(SI = Conventional Units X 2.09)						
Gentamicin						
(Standard dosing)						
Peak	6–10 mcg/mL	12–21 micromol/L	4–8	0.4–1.3	50	1° renal
Trough	0.5–1.5 mcg/mL	1–3 micromol/L				
(SI = Conventional Units X 2.14)						
Tobramycin						
Peak	6–10 mcg/mL	13–21 micromol/L	4–8	0.4–1.3	50	1° renal
Trough	0.5–1.5 mcg/mL	1–3 micromol/L				
(SI = Conventional Units X 0.69)						
Vancomycin						
Peak	30–40 mcg/mL	21–28 micromol/L	4–8	0.4–1.3	50	1° renal
Trough	5–10 mcg/mL	3–7 micromol/L				

*Conventional units.

DESCRIPTION: The aminoglycoside antibiotics amikacin, gentamicin, and tobramycin are used against many gram-negative (*Acinetobacter*, *Citrobacter*, *Enterobacter*, *Escherichia coli*, *Klebsiella*, *Proteus*, *Providencia*, *Pseudomonas*, *Raoultella*, *Salmonella*, *Serratia*, *Shigella*, and *Stenotrophomonas*) and some gram-positive (*Staphylococcus aureus*) pathogenic microorganisms. Aminoglycosides are poorly absorbed through the gastrointestinal tract and are most frequently administered IV.

Vancomycin is a tricyclic glycopeptide antibiotic used against many gram-positive microorganisms, such as staphylococci, *Streptococcus pneumoniae*, group A β -hemolytic streptococci, enterococci, *Corynebacterium*, and *Clostridium*. Vancomycin has also been used in an oral form for the treatment of pseudomembranous colitis resulting from *Clostridium difficile* infection. This approach is less frequently used because of the emergence of vancomycin-resistant enterococci (VRE).

Many factors must be considered in effective dosing and monitoring of therapeutic drugs, including patient age, patient weight, interacting medications, electrolyte balance, protein levels, water balance, conditions that affect absorption and excretion, and ingestion of substances (e.g., foods, herbals,

vitamins, and minerals) that can either potentiate or inhibit the intended target concentration. The most serious side effects of the aminoglycosides and vancomycin are nephrotoxicity and irreversible ototoxicity (uncommon). Peak and trough collection times should be documented carefully in relation to the time of medication administration. Creatinine levels should be monitored every 2 to 3 days to detect renal impairment due to toxic drug levels.

IMPORTANT NOTE:


This information must be clearly and accurately communicated to avoid misunderstanding of the dose time in relation to the collection time. Miscommunication between the individual administering the medication and the individual collecting the specimen is the most frequent cause of subtherapeutic levels, toxic levels, and misleading information used in the calculation of future doses. Some pharmacies use a computerized pharmacokinetics approach to dosing that eliminates the need to be concerned about peak and trough collections; random specimens are adequate.

INDICATIONS:

- Assist in the diagnosis and prevention of toxicity
- Monitor renal dialysis patients or patients with rapidly changing renal function
- Monitor therapeutic regimen

RESULT:

Level	Result
Normal levels	Therapeutic effect
Subtherapeutic levels	Adjust dose as indicated
Toxic levels	Adjust dose as indicated
<i>Amikacin</i>	Renal, hearing impairment
<i>Gentamicin</i>	Renal, hearing impairment
<i>Tobramycin</i>	Renal, hearing impairment
<i>Vancomycin</i>	Renal, hearing impairment

CRITICAL VALUES:  The adverse effects of subtherapeutic levels are important. Care should be taken to investigate signs and symptoms of too little and too much medication. Note and immediately report to the health care provider (HCP) any critically increased or subtherapeutic values and related symptoms.

Signs and symptoms of toxic levels of these antibiotics are similar and include loss of hearing and decreased renal function. The most important intervention is accurate therapeutic drug monitoring so the medication can be discontinued before irreversible damage is done.

Drug Name	Toxic Levels
Amikacin	Peak greater than 30 mcg/mL, trough greater than 8 mcg/mL
Gentamicin	Peak greater than 12 mcg/mL, trough greater than 2 mcg/mL
Tobramycin	Peak greater than 12 mcg/mL, trough greater than 2 mcg/mL
Vancomycin	Peak greater than 80 mcg/mL, trough greater than 20 mcg/mL

INTERFERING FACTORS:

- Blood drawn in serum separator tubes (gel tubes).
- Contraindicated in patients with liver disease, and caution advised in patients with renal impairment.
- Drugs that may decrease aminoglycoside efficacy include bleomycin, daunorubicin, doxorubicin, and penicillins (e.g., carbenicillin, piperacillin).
- Obtain a culture before and after the first dose of aminoglycosides.
- The risks of ototoxicity and nephrotoxicity are increased by the concomitant administration of aminoglycosides.

- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Note the last time and dose of medication taken.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions unless by medical direction.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to monitor for therapeutic and toxic drug levels.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Consider recommended collection time in relation to the dosing schedule. Positively identify the patient and label the appropriate tubes with the corresponding patient demographics, date, and time of collection, noting the last dose of medication taken. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient receiving aminoglycosides to immediately report any unusual symptoms (e.g., hearing loss, decreased urinary output) to his or her HCP.
- ▶ *Nutritional considerations:* include the avoidance of alcohol consumption.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of

the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain to the patient the importance of following the medication regimen and instructions regarding food and drug interactions. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient to be prepared to provide the pharmacist with a list of other medications he or she is already taking in the event that the requesting HCP prescribes a medication.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include albumin, BUN, creatinine, creatinine clearance, cultures bacterial (ear, eye, skin, wound, blood, stool, sputum), potassium, and UA.
- ▶ See the Genitourinary System table for related tests by body system.

Antibodies, Anti-Cyclic Citrullinated Peptide

SYNONYM/ACRONYM: anti-CCP antibodies.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: IgG Ab (Method: Immunoassay, Enzyme Linked Immunosorbent Assay [ELISA])

Negative	Less than 20 Units
Weak Positive	20–39 Units
Moderate Positive	40–59 Units
Strong Positive	60 Units or Greater

DESCRIPTION: Rheumatoid arthritis (RA) is a chronic, systemic autoimmune disease that damages the joints. Inflammation caused by autoimmune responses can affect other organs and body systems. The current American Academy of Rheumatology criteria state that a patient must have four of seven criteria to be diagnosed with RA: morning stiffness, arthritis of three or more joint areas, arthritis of hand joints, symmetric arthritis, rheumatoid nodules, abnormal amounts of rheumatoid factor, and radiographic changes. The study of RA is complex and it is believed that multiple genes may be involved in the manifestation of RA. Scientific research has revealed an unusual peptide conversion from arginine to citrulline that results in formation of antibodies whose presence provides the basis for this test. Studies show that detection of antibodies formed against citrullinated peptides is specific and sensitive in detecting RA in both early and established disease. Anti-CCP assays have 96% specificity and 78% sensitivity for RA, vs the traditional IgM Rheumatoid Factor (RF) marker with a specificity of 60% to 80% and sensitivity of 75% to 80% for RA. Anti-CCP antibodies are being used as a marker for erosive disease in RA and the antibodies have been detected in healthy patients years before the onset of RA symptoms and diagnosed disease. Some

studies have shown that as many as 40% of patients seronegative for RF are anti-CCP positive. The combined presence of RF and anti-CCP has a 99.5% specificity for RA. Women are two to three times more likely to develop RA than men. While RA is most likely to affect people aged 35–50, it can affect all ages.

INDICATIONS:

- Assist in the diagnosis of RA in both symptomatic and asymptomatic individuals
- Assist in the identification of erosive disease in RA
- Assist in the diagnostic prediction of RA development in undifferentiated arthritis

RESULT:

Increased in:

- RA (*The immune system produces antibodies that attack the joint tissues. Inflammation of the synovium, or membrane that lines the joint, begins a process called synovitis. If untreated the synovitis can expand beyond the joint tissue to surrounding ligaments, tissues, nerves, and blood vessels.*)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Explain to the patient that the test is primarily used to assist in the diagnosis of unexplained joint inflammation, especially when RF test results are negative.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and musculoskeletal system, symptoms, and results of previously performed laboratory tests, diagnostic, and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to anticipated chronic pain resulting from joint inflammation, impairment in mobility, muscular deformity, and perceived loss of independence. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results as appropriate. Explain the importance of physical activity in the treatment plan. Educate the patient regarding access to physical therapy, occupational therapy, and counseling services. Provide contact information, if desired, for the Arthritis Foundation (www.arthritis.org). Encourage the patient to take medications as ordered. Treatment with disease-modifying antirheumatic drugs (DMARDs) and biologic response modifiers may take as long as 2 to 3 mo to demonstrate their effects.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy.

RELATED MONOGRAPHS:

- ▶ Related laboratory tests include ANA, arthroscopy, BMD, bone scan, CRP, ESR, MRI musculoskeletal, radiography bone, RF, synovial fluid analysis, and uric acid.
- ▶ Refer to the Immune and Musculoskeletal System tables at the back of the book for related tests by body system.

Antibodies, Anti-Glomerular Basement Membrane

A

SYNONYM/ACRONYM: Goodpasture's antibody, anti-GBM.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Lung or kidney tissue also may be submitted for testing. Refer to related biopsy monographs for specimen collection instructions.

REFERENCE VALUE: (Method: Direct or indirect immunofluorescence) Negative.

DESCRIPTION: Goodpasture's syndrome is a rare hypersensitivity condition characterized by the presence of circulating anti-glomerular basement membrane antibodies in the blood and the deposition of immunoglobulin and complement in renal basement membrane tissue. Severe and progressive glomerulonephritis can result from the presence of antibodies to renal glomerular basement membrane (GBM). Autoantibodies may also be directed to act against lung tissue in Goodpasture's syndrome.

INDICATIONS:

- Differentiate glomerulonephritis caused by anti-GBM from glomerulonephritis from other causes

RESULT:

Increased in:

- Glomerulonephritis
- Goodpasture's syndrome (*nephritis of autoimmune origin*)
- Idiopathic pulmonary hemosiderosis

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to assist in detection and monitoring of glomerular basement membrane antibodies present in Goodpasture's syndrome.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's genitourinary, immune, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ◆ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

- ◆ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ANCA, biopsy kidney, biopsy lung, IVP, renogram, US kidney, and UA.
- ◆ See the Genitourinary, Immune, and Respiratory System tables at the back of the book for related tests by body system.

Antibodies, Antimitochondrial and Antismooth Muscle

SYNONYM/ACRONYM: AMA, ASMA.

SPECIMAN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect fluorescent antibody)

AMA Negative or titer less than 1:20.

ASMA Negative.

DESCRIPTION: Antimitochondrial antibodies are found in 90% of patients with primary biliary cirrhosis (PBC). PBC is identified most frequently in women aged 35 to 60. Testing is useful in the differential diagnosis of chronic liver disease as antimitochondrial antibodies are rarely detected in extrahepatic biliary obstruction, various forms of hepatitis, and cirrhosis. Antismooth muscle antibodies are autoantibodies found in high titers in the sera of patients with autoimmune diseases of the liver and bile duct. Simultaneous testing for antimitochondrial antibodies can be useful in the differential diagnosis of chronic liver disease.

INDICATIONS:

- AMA
- Assist in the diagnosis of PBC
- Assist in the differential diagnosis of chronic liver disease
- ASMA
- Differential diagnosis of liver disease

RESULT:

Increased in:

- AMA
- Hepatitis (alcoholic, viral)
- PBC
- Rheumatoid arthritis (occasionally)
- Systemic lupus erythematosus (occasionally)
- Thyroid disease (occasionally)
- ASMA
- Autoimmune hepatitis
- Chronic active viral hepatitis
- Infectious mononucleosis

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used in the differential diagnosis of chronic liver disease.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's hepatobiliary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ♦ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Nutritional considerations:** The presence of antimitochondrial or antismooth muscle antibodies may be associated with liver disease. Dietary recommendations may be indicated and vary depending on the severity of the condition. A low-protein diet may be in order if the liver cannot process the end products of protein metabolism. A diet of soft foods may be required if esophageal varices have developed. Ammonia levels may be used to determine whether protein should be added to or reduced from the diet. Patients should be encouraged to eat simple carbohydrates and emulsified fats (as in homogenized milk or eggs), as

opposed to complex carbohydrates (e.g., starch, fiber, and glycogen [animal carbohydrates]) and complex fats, which require additional bile to emulsify them so that they can be used.

- Observe the cirrhotic patient carefully for the development of ascites; if ascites develops, pay strict attention to fluid and electrolyte balance.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include albumin, ALP, ammonia, ANCA, ANA, bilirubin, biopsy liver, electrolytes, and GGT.
- See the Hepatobiliary and Immune System tables at the back of the book for related tests by body system.

Antibodies, Antineutrophilic Cytoplasmic

SYNONYM/ACRONYM: Cytoplasmic antineutrophil cytoplasmic antibody (c-ANCA), perinuclear antineutrophil cytoplasmic antibody (p-ANCA).

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect immunofluorescence) Negative.

DESCRIPTION: There are two types of cytoplasmic neutrophil antibodies (ANCA), identified by their cellular staining characteristics. c-ANCA (cytoplasmic) is specific for proteinase 3 in neutrophils and monocytes and is found in the sera of patients

with Wegener's granulomatosis. Wegener's syndrome includes granulomatous inflammation of the upper and lower respiratory tract and vasculitis. p-ANCA (perinuclear) is specific for myeloperoxidase, elastase, and lactoferrin, as well as other

enzymes in neutrophils. p-ANCA is present in the sera of patients with pauci-immune necrotizing glomerulonephritis.

INDICATIONS:

- Assist in the diagnosis of Wegener's granulomatosis and its variants
- Differential diagnosis of ulcerative colitis
- Distinguish between biliary cirrhosis and sclerosing cholangitis
- Distinguish between vasculitic disease and the effects of therapy

RESULT:

Increased in:

- ***The exact mechanism by which ANCA are developed is unknown. One theory suggests colonization with bacteria capable of expressing microbial superantigens. It is thought that the superantigens may stimulate a strong cellular autoimmune response in genetically susceptible individuals. Another theory suggests the immune system may be stimulated by an accumulation of the antigenic targets of ANCA due to ineffective destruction of old neutrophils or ineffective removal of neutrophil cell fragments containing proteinase, myeloperoxidase, elastase, lactoferrin, or other proteins.***
- c-ANCA
Wegener's granulomatosis and its variants
- p-ANCA
Alveolar hemorrhage
Angiitis and polyangiitis
Autoimmune liver disease
Capillaritis
Churg-Strauss syndrome
Felty's syndrome

Glomerulonephritis
Inflammatory bowel disease
Leukocytoclastic skin vasculitis
Necrotizing-crescentic
glomerulonephritis
Rheumatoid arthritis
Vasculitis

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis and monitoring of inflammatory activity in primary systemic small vessel vasculitides.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal, genitourinary, hepatobiliary, immune, and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure the gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of

abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies, anti-glomerular basement membrane, AMA/ASMA, ANA, biopsy kidney, eosinophil count, and RF.
- ▶ See the Gastrointestinal, Genitourinary, Hepatobiliary, Immune, and Musculoskeletal System tables at the back of the book for related tests by body system.

Antibodies, Antinuclear, Anti-DNA, Anticentromere, Antiextractable Nuclear Antigen, and Antiscleroderma

SYNONYM/ACRONYM: Antinuclear antibodies (ANA), anti-DNA (anti-ds DNA), antiextractable nuclear antigens (anti-ENA, ribonucleoprotein [RNP], Smith [Sm], SS-A/Ro, SS-B/La), anti-Jo (antihistidyl transfer RNA [tRNA] synthase), and antiscleroderma (progressive systemic sclerosis [PSS] antibody, Scl-70 antibody, topoisomerase I antibody).

SPECIMEN: Serum (3 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect fluorescent antibody for ANA and anticentromere; enzyme-linked immunosorbent assay [ELISA] for anti-DNA; immunodiffusion for ENA and Scl-70)

ANA and anticentromere: titer of 1:40 or less. Anti-ENA and anti-Scl-70: Negative.

ANTI-DNA:

Negative	Less than 24 international units
Borderline	25–30 international units
Positive	31–200 international units
Strong positive	Greater than positive 200 international units

DESCRIPTION: Atinuclear antibodies (ANA) are autoantibodies mainly located in the nucleus of affected cells. The presence of ANA indicates systemic lupus erythematosus (SLE), related collagen vascular diseases, and immune complex diseases. Antibodies against cellular DNA are strongly associated with SLE. Anticentromere antibodies are a subset of ANA. Their presence is strongly associated with CREST syndrome (calcinosis, Raynaud's phenomenon, esophageal dysfunction, sclerodactyly, and telangiectasia). Women are much more likely than men to be diagnosed with SLE. The extractable nuclear antigens (ENAs) include ribonucleoprotein (RNP), Smith (Sm), SS-A/Ro, and SS-B/La antigens. ENAs and antibodies to them are found in various combinations in individuals with combinations of overlapping rheumatologic symptoms. The American College of Rheumatology issued a list of 11 signs and/or symptoms in 1982 to assist in differentiating lupus from other similar diseases. The patient should have four or more of these to establish suspicion of lupus; the symptoms do not have to manifest at the same time: malar rash (rash over the cheeks), discoid rash (red raised patches), photosensitivity (exposure resulting in development of

or increase in skin rash), oral ulcers, nonerosive arthritis involving two or more peripheral joints, pleuritis or pericarditis, renal disorder (as evidenced by excessive protein in urine or the presence of casts in the urine), neurologic disorder (seizures or psychosis in the absence of drugs known to cause these effects), hematologic disorder (hemolytic anemia, leukopenia, lymphopenia, thrombocytopenia where the leukopenia or lymphopenia occurs on more than two occasions and the thrombocytopenia occurs in the absence of drugs known to cause it), positive ANA in the absence of a drug known to induce lupus, or immunologic disorder (evidenced by positive anti-ds DNA, positive anti-Sm, positive antiphospholipid such as anticardiolipin antibody or a false-positive VDRL syphilis test).

INDICATIONS:

- Assist in the diagnosis and evaluation of SLE
- Assist in the diagnosis and evaluation of suspected immune disorders, such as rheumatoid arthritis, systemic sclerosis, polymyositis, Raynaud's syndrome, scleroderma, Sjögren's syndrome, and mixed connective tissue disease
- Assist in the diagnosis and evaluation of idiopathic inflammatory myopathies

RESULT:

ANA Pattern*	Associated Antibody	Associated Condition
Rim and/or homogeneous	Double-stranded DNA	SLE
	Single- or double-stranded DNA	
Homogeneous	Histones	SLE
Speckled	Sm (Smith) antibody	SLE, mixed connective tissue disease, Raynaud's scleroderma, Sjögren's syndrome
	RNP*	Mixed connective tissue disease, various rheumatoid conditions
	SS-B/La, SS-A/Ro	Various rheumatoid conditions
Diffuse speckled with positive mitotic figures	Centromere	PSS with CREST, Raynaud's
Nucleolar	Nucleolar, RNP	Scleroderma, CREST

*ANA patterns are helpful in that certain conditions are frequently associated with specific patterns. RNP = ribonucleoprotein.

Increased in:

- Anti-Jo-1 *is associated with dermatomyositis, idiopathic inflammatory myopathies, and polymyositis*
- ANA *is associated with drug-induced lupus erythematosus*
- ANA *is associated with lupoid hepatitis*
- ANA *is associated with mixed connective tissue disease*
- ANA *is associated with polymyositis*
- ANA *is associated with progressive systemic sclerosis*
- ANA *is associated with Raynaud's syndrome*
- ANA *is associated with rheumatoid arthritis*
- ANA *is associated with Sjögren's syndrome*
- ANA *and anti-DNA are associated with SLE*
- Anti-RNP *is associated with mixed connective tissue disease*

- Anti-Scl 70 *is associated with progressive systemic sclerosis and scleroderma*
- Anti-SS-A and anti-SS-B *are helpful in antinuclear antibody (ANA)-negative cases of SLE*
- Anti-SS-A/ANA-positive, anti-SS-B-negative patients *are likely to have nephritis*
- Anti-SS-A/anti-SS-B-positive sera *are found in patients with neonatal lupus*
- Anti-SS-A-positive patients *may also have antibodies associated with antiphospholipid syndrome*
- Anti-SS-A/La *is associated with primary Sjögren's syndrome*
- Anti-SS-A/Ro *is a predictor of congenital heart block in neonates born to mothers with SLE*
- Anti-SS-A/Ro-positive patients *have photosensitivity*

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may cause positive ANA results include carbamazepine, chlorpromazine, ethosuximide, hydralazine, isoniazid, mephenytoin, methyl dopa, penicillins, phenytoin, primidone, procainamide, and quinidine.
- A patient can have lupus and test ANA-negative.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- Inform the patient that the test is used to detect the presence of antibodies associated with autoimmune disorders such as systemic lupus erythematosus and mixed connective tissue disease.
- Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- Obtain a history of the patient's immune and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Collagen and connective tissue diseases are chronic and, as such, they must be addressed on a continuous basis. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the Lupus Foundation of America (<http://www.lupus.org>).
- Educate the patient, as appropriate, regarding the importance of preventing infection, which is a significant cause of death in immunosuppressed individuals.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antibodies, anticyclic citrullinated peptide, arthroscopy, biopsy kidney, biopsy skin, BMD, bone scan, chest x-ray, complement C3 and C4, complement total, CRP, ESR, EMG, MRI musculoskeletal, procainamide, radiography bone, RF, and synovial fluid analysis.
- See the Immune and Musculoskeletal System tables in the back of the book for related tests by body system.

Antibodies, Antisperm

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Result	Sperm Bound by Immunobead (%)
Negative	0–15
Weak positive	16–30
Moderate positive	31–50
Strong positive	51–100

DESCRIPTION: Normally sperm develop in the seminiferous tubules of the testes separated from circulating blood by the blood-testes barrier. Any situation that disrupts this barrier can expose sperm to detection by immune response cells in the blood and subsequent antibody formation against the sperm.

Antisperm antibodies attach to the head, midpiece, or tail of the sperm, impairing motility and ability to penetrate the cervical mucosa. The antibodies can also cause clumping of sperm, which may be noted on a semen analysis. A major cause of infertility in men is blocked efferent testicular ducts. Reabsorption of sperm from the blocked ducts may also result in development of sperm antibodies. Another more specific and sophisticated method than measurement of circulating antibodies is the immunobead sperm antibody test used to identify antibodies directly attached to the sperm. Semen and cervical mucus can also be tested for antisperm antibodies.

INDICATIONS:

- Evaluation of infertility

RESULT:**Increased in:**

- **Conditions that affect the integrity of the blood-testes barrier can result in antibody formation.**
- Blocked testicular efferent duct
- Congenital absence of the vas deferens
- Cryptorchidism
- Infection (orchitis, prostatitis)
- Inguinal hernia repair prior to puberty
- Testicular biopsy
- Testicular cancer
- Testicular torsion
- Varicocele
- Vasectomy reversal

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- The patient should not ejaculate for 3 to 4 days before specimen collection if semen will be evaluated.
- Sperm antibodies have been detected in pregnant women and in women with primary infertility.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used in the evaluation of infertility and guidance through assisted reproductive techniques.
- ▶ Obtain a history of the patient's complaints, including a list of known

allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's immune and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min and that additional specimens may be required. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider

(HCP), who will discuss the results with the patient.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Educate the patient regarding access to counseling services. Provide a supportive, nonjudgmental environment when assisting a patient through the process of fertility testing. Educate the patient regarding access to counseling services, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include HCG, LH, progesterone, semen analysis, testosterone, and US scrotal.
- ▶ See the Immune and Reproductive System tables at the back of the book for related tests by body system.

Antibodies, Antistreptolysin O

SYNONYM/ACRONYM: Streptozyme, ASO.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Nephelometry) Less than 200 international units/mL.

DESCRIPTION: Group A β -hemolytic streptococci secrete the enzyme streptolysin O, which can destroy red blood cells. The enzyme acts as an antigen and stimulates the immune system to develop streptolysin O antibodies. These antistreptolysin O (ASO) antibodies occur within 1 mo after the onset of a streptococcal infection. Detection of the antibody over several weeks strongly suggests exposure to group A β -hemolytic streptococci.

INDICATIONS:

- Assist in establishing a diagnosis of streptococcal infection
- Evaluate patients with streptococcal infections for the development of acute rheumatic fever or nephritis
- Monitor response to therapy in streptococcal illnesses

RESULT:

Increased in:

- **Presence of antibodies, especially a rise in titer, is indicative of exposure**
- Endocarditis
- Glomerulonephritis

- Rheumatic fever
- Scarlet fever

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may decrease ASO titers include antibiotics and corticosteroids, because therapy suppresses antibody response.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to document exposure to group A streptococci bacteria.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Administer antibiotics as ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy even if signs and symptoms disappear before completion of therapy.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include culture throat, group A streptococcal screen, and streptococcal anti-DNAse B.
- ▶ See the Cardiovascular, Genitourinary, and Immune System tables in the back of the book for related tests by body system.

Antibodies, Antithyroglobulin and Antithyroid Peroxidase

SYNONYM/ACRONYM: Thyroid antibodies, antithyroid peroxidase antibodies (thyroid peroxidase [TPO] antibodies were previously called thyroid antimicrosomal antibodies).

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Antibody	Conventional Units
Antithyroglobulin antibody	Less than 20 units/mL
Antiperoxidase antibody	Less than 35 units/mL

DESCRIPTION: Thyroid antibodies are mainly immunoglobulin G-type antibodies. Antithyroid peroxidase antibodies bind with microsomal antigens on cells lining the microsomal membrane. They are thought to destroy thyroid tissue as a result of stimulation by lymphocytic killer cells. These antibodies are present in hypothyroid and hyperthyroid conditions. Anti-thyroglobulin antibodies are autoantibodies directed against thyroglobulin. The function of these antibodies is unclear. Both tests are normally requested together.

INDICATIONS:

- Assist in confirming suspected inflammation of thyroid gland
- Assist in the diagnosis of suspected hypothyroidism caused by thyroid tissue destruction
- Assist in the diagnosis of suspected thyroid autoimmunity in patients with other autoimmune disorders

RESULT:

Increased in:

The presence of these antibodies differentiates the autoimmune origin of these disorders from non-autoimmune causes, which may influence treatment decisions

- Autoimmune disorders
- Graves' disease
- Goiter
- Hashimoto's thyroiditis
- Idiopathic myxedema
- Pernicious anemia
- Thyroid carcinoma

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Lithium may increase thyroid antibody levels.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ◆ Inform the patient that the test is used to assess thyroid gland function.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's endocrine and immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Note any recent procedures that can interfere with test results.
- ◆ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient

- demographics, date, and time of collection. Perform a venipuncture.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include biopsy thyroid, complete blood count, FT₃, FT₄, RAIU, T4, thyroid scan, thyroglobulin, TSH, TT3, and US thyroid.
- ◆ See the Endocrine and Immune System tables at the back of the book for related tests by body system.

Antibodies, Cardiolipin, Immunoglobulin G, and Immunoglobulin M

SYNONYM/ACRONYM: Antiphospholipid antibody, lupus anticoagulant, LA, ACA.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Immunoassay, enzyme-linked immunosorbent assay [ELISA]) Negative.

DESCRIPTION: Cardiolipin antibody is one of several identified antiphospholipid antibodies. These antibodies react with proteins in the blood that are bound to phospholipid and interfere with normal blood vessel function. The two primary types of problems they cause are narrowing and irregularity of the blood vessels and blood clots in the blood vessels. Cardiolipin antibodies are found in individuals with lupus erythematosus, lupus-related conditions, infectious diseases, drug reactions, and sometimes fetal loss. Cardiolipin antibodies are often found in association with lupus anticoagulant. Increased antiphospholipid antibody levels have been found in pregnant women with lupus who have had miscarriages. The combination of noninflammatory thrombosis of blood vessels, low platelet count, and history of miscarriage is termed *antiphospholipid antibody syndrome*.

INDICATIONS:

- Assist in the diagnosis of antiphospholipid antibody syndrome

RESULT:

Increased in:

- Antiphospholipid antibody syndrome
- Chorea
- Drug reactions
- Epilepsy
- Infectious diseases
- Mitral valve endocarditis
- Patients with lupuslike symptoms (often antinuclear antibody–negative)
- Placental infarction
- Recurrent fetal loss (strong association with two or more occurrences)
- Recurrent venous and arterial thromboses

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Cardiolipin antibody is partially cross-reactive with syphilis reagent antibody and lupus anticoagulant. False-positive rapid plasma reagent results may occur.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to detect the presence of antiphospholipid antibodies, which can lead to the development of blood vessel problems, complications of which include stroke, heart attack, and miscarriage.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic, immune, and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the

clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the Lupus Foundation of America (www.lupus.org).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ANA, complete blood count, fibrinogen, lupus anticoagulant antibodies, complete blood count, platelet count, protein C, protein S, and syphilis serology.
- ▶ See the Hematopoietic, Immune, and Reproductive System tables in the back of the book for related tests by body system.

Antibodies, Gliadin (Immunoglobulin G and Immunoglobulin A)

SYNONYM/ACRONYM: Endomysial antibodies, gliadin (IgG and IgA) antibodies, EMA.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Immunoassay)

IgA and IgG Gliadin Antibody	Conventional Units
Age	
0–2 yr	Less than 50 units/mL
2 yr–Adult	Less than 25 units/mL

DESCRIPTION: Gliadin is a water-soluble protein found in the gluten of wheat, rye, oats, and barley. The intestinal mucosa of certain individuals does not digest gluten, allowing a toxic

buildup of gliadin. Antibodies to gliadin form and result in damage to the intestinal mucosa. In severe cases, immunoglobulin G (IgG) and immunoglobulin A (IgA) gliadin antibodies are detectable in the serum of patients with gluten-sensitive enteropathy.

INDICATIONS:

- Assist in the diagnosis of asymptomatic gluten-sensitive enteropathy in some patients with dermatitis herpetiformis
- Assist in the diagnosis of gluten-sensitive enteropathies
- Assist in the diagnosis of nontropical sprue
- Monitor dietary compliance of patients with gluten-sensitive enteropathies

RESULT:

Increased in:

- Asymptomatic gluten-sensitive enteropathy
- Celiac disease
- Dermatitis herpetiformis
- Nontropical sprue

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Conditions other than gluten-sensitive enteropathy can result in elevated antibody levels without corresponding histologic evidence. These conditions include Crohn's disease, postinfection malabsorption, and food protein intolerance.
- A negative IgA gliadin result, especially with a positive IgG gliadin result in an untreated patient, does not rule out active gluten-sensitive enteropathy.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis and monitoring of gluten-sensitive enteropathies.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of foods and the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Encourage the patient with abnormal findings to consult with a qualified nutritionist to plan a gluten-free diet. This dietary planning is complex because patients are often malnourished and have other related nutritional problems.
- ▶ Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to appropriate counseling services. Provide contact information, if desired, for the Celiac Disease Foundation (celiac.org).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include albumin, biopsy intestine, biopsy skin, calcium, capsule endoscopy, colonoscopy, D-xylose tolerance test, electrolytes, fecal analysis, fecal fat, folic acid, iron, and lactose tolerance test.
- ▶ See the Gastrointestinal and Immune System tables in the back of the book for related tests by body system.

Anticonvulsant Drugs: Carbamazepine, Ethosuximide, Phenobarbital, Phenytoin, Primidone, Valproic Acid

SYNONYM/ACRONYM: *Carbamazepine* (Carbatrol, Tegretol, Tegretol XR); *ethosuximide* (Zarontin); *phenobarbital* (Luminal, Phenobarb); *phenytoin* (Cerebyx, Dilantin, Fenytoin, Phenytek); *primidone* (Mysoline); *valproic acid* (Depacon, Depakene, Depakote).

SPECIMEN: Serum (1 mL) collected in a red-top tube.

Drug	Route of Administration
Carbamazepine*	Oral
Ethosuximide*	Oral
Phenobarbital*	Oral
Phenytoin*	Oral
Primidone*	Oral
Valproic Acid*	Oral

*Recommended collection time = trough: immediately before next dose (at steady state) or at a consistent sampling time.

REFERENCE VALUE: (Method: Immunoassay)

Drug	Therapeutic Dose*	SI Units	Half-Life (hr)	Volume of Distribution (L/kg)	Protein Binding (%)	Excretion
(SI = Conventional Units \times 4.23) Carbamazepine	4–12 mcg/mL	17–51 micromol/L	15–40	0.8–1.8	60–80	Hepatic
(SI = Conventional Units \times 7.08) Ethosuximide	40–100 mcg/mL	283–708 micromol/L	25–70	0.7	0–5	Renal
(SI = Conventional Units \times 4.31) Phenobarbital	Adult: 15–40 mcg/mL Child: 15–30 mcg/mL	Adult: 65–172 micromol/L Child: 65–129 micromol/L	Adult: 50–140 Child: 40–70	0.5–1.0 L/kg	40–50	80% Hepatic 20% Renal
(SI = Conventional Units \times 3.96) Phenytoin	10–20 mcg/mL Neonatal: 6–14 mcg/mL	40–79 micromol/L Neonatal: 24–55 micromol/L	Adult: 20–40 Child: 10	0.6–0.7	85–95	Hepatic
(SI = Conventional Units \times 4.58) Primidone	Adult: 5–12 mcg/mL Child: 7–10 mcg/mL	Adult: 23–55 micromol/L Child: 32–46 micromol/L	4–12	0.5–1.0	0–20	Hepatic
(SI = Conventional Units \times 6.93) Valproic Acid	50–120 mcg/mL	347–832 micromol/L	12–16	0.1–0.5	85–95	Hepatic

*Conventional units.

DESCRIPTION: Anticonvulsants are used to reduce the frequency and severity of seizures for patients with epilepsy. Carbamazepine is also used for controlling neurogenic pain in trigeminal neuralgia and diabetic neuropathy and for treating bipolar disease and other neurologic and psychiatric conditions. Valproic acid is also used for some psychiatric conditions like bipolar disease and for prevention of migraine headache.

Many factors must be considered in effective dosing and monitoring of therapeutic drugs, including patient age, patient weight, interacting medications, electrolyte balance, protein levels, water balance, conditions that affect absorption and excretion, and foods, herbals, vitamins, and minerals that can either potentiate or inhibit the intended target concentration.

Peak and trough collection times should be documented carefully in relation to the time of medication administration.

IMPORTANT NOTE: This information must be clearly and accurately communicated to avoid misunderstanding of the dose time in relation to the collection time. Miscommunication between the individual administering the medication and the individual collecting the specimen is the most frequent cause of subtherapeutic levels, toxic levels, and misleading information used in calculation of future doses.


INDICATIONS:

- Assist in the diagnosis of and prevention of toxicity
- Evaluate overdose, especially in combination with ethanol
- Monitor compliance with therapeutic regimen

RESULT:

Level	Response
Normal levels	Therapeutic effect
Subtherapeutic levels	Adjust dose as indicated
Toxic levels	Adjust dose as indicated
<i>Carbamazepine</i>	Hepatic impairment
<i>Ethosuximide</i>	Hepatic impairment
<i>Phenobarbital</i>	Hepatic impairment
<i>Phenytoin</i>	Hepatic impairment
<i>Primidone</i>	Hepatic impairment
<i>Valproic acid</i>	Hepatic impairment

CRITICAL VALUES:

 It is important to note the adverse effects of toxic and subtherapeutic levels. Care must be taken to investigate the signs and symptoms of too little and too much medication. Note and immediately report to the health care provider (HCP) any critically increased or subtherapeutic values and related symptoms.

Carbamazepine: Greater Than 12 mcg/mL

Signs and symptoms of carbamazepine toxicity include respiratory depression, seizures, leukopenia, hyponatremia, hypotension, stupor, and possible coma. Possible interventions include gastric lavage (contraindicated if ileus is present); airway protection; administration of fluids

and vasopressors for hypotension; treatment of seizures with diazepam, phenobarbital, or phenytoin; cardiac monitoring; monitoring of vital signs; and discontinuing the medication. Emetics are contraindicated.

Ethosuximide: Greater Than 100 mcg/mL

Signs and symptoms of ethosuximide toxicity include nausea, vomiting, and lethargy. Possible interventions include administration of activated charcoal, administration of saline cathartic and gastric lavage (contraindicated if ileus is present), airway protection, hourly assessment of neurologic function, and discontinuing the medication.

Phenobarbital: Greater Than 40 mcg/mL

Signs and symptoms of phenobarbital toxicity include cold, clammy skin; ataxia; central nervous system (CNS) depression; hypothermia; hypotension; cyanosis; Cheyne-Stokes respiration; tachycardia; possible coma; and possible renal impairment. Possible interventions include gastric lavage, administration of activated charcoal with cathartic, airway protection, possible intubation and mechanical ventilation (especially during gastric lavage if there is no gag reflex), monitoring for hypotension, and discontinuing the medication.

Phenytoin: Adults: Greater Than 20 mcg/mL; Neonatal: Greater Than 14 mcg/mL

Signs and symptoms of phenytoin toxicity include double vision, nystagmus, lethargy, CNS depression, and possible coma. Possible interventions include airway support, electrocardiographic monitoring, administration of activated charcoal, gastric lavage with warm saline or tap water, administration of saline or sorbitol cathartic, and discontinuing the medication.

Primidone: Greater Than 12 mcg/mL

Signs and symptoms of primidone toxicity include ataxia, anemia, and CNS depression. Possible interventions include airway protection, treatment of anemia with vitamin B₁₂ and folate, and discontinuing the medication.

Valproic Acid: Greater Than 120 mcg/mL

Signs and symptoms of valproic acid toxicity include numbness, tingling, weakness, loss of appetite, and mental changes. Possible interventions include administration of activated charcoal and naloxone and discontinuing the medication.

INTERFERING FACTORS:

- Blood drawn in serum separator tubes (gel tubes).
- Contraindicated in patients with liver disease, and caution advised in patients with renal impairment.
- Drugs that may increase carbamazepine levels or increase risk of toxicity include acetazolamide, azithromycin, bepridil, cimetidine, danazol, diltiazem, erythromycin, felodipine, fluoxetine, flurithromycin, fluvoxamine, gemfibrozil, isoniazid, itraconazole, josamycin, ketoconazole, lorazepam, macrolides, niacinamide, nifedipine, nimodipine, nisoldipine, propoxyphene, ritonavir, terfenadine, troleanomycin, valproic acid, verapamil, and viloxazine.
- Drugs that may decrease carbamazepine levels include phenobarbital, phenytoin, and primidone.
- Drugs that may increase ethosuximide levels include isoniazid, ritonavir, and valproic acid.
- Drugs that may decrease ethosuximide levels include phenobarbital, phenytoin, and primidone.
- Drugs that may increase phenobarbital levels or increase risk of

toxicity include barbitol drugs, furosemide, primidone, salicylates, and valproic acid.

- Phenobarbital may affect the metabolism of other drugs, increasing their effectiveness, such as β -blockers, chloramphenicol, corticosteroids, doxycycline, griseofulvin, haloperidol, methylphenidate, phenothiazines, phenylbutazone, propoxyphene, quinidine, theophylline, tricyclic antidepressants, and valproic acid.
- Phenobarbital may affect the metabolism of other drugs, decreasing their effectiveness, such as chloramphenicol, cyclosporine, ethosuximide, oral anticoagulants, oral contraceptives, phenytoin, and theophylline.
- Phenobarbital is an active metabolite of primidone, and both drug levels should be monitored while the patient is receiving primidone to avoid either toxic or subtherapeutic levels of both medications.
- Drugs that may increase phenytoin levels or increase the risk of phenytoin toxicity include amiodarone, azapropazone, carbamazepine, chloramphenicol, cimetidine, disulfiram, ethanol, fluconazole, halothane, ibuprofen, imipramine, levodopa, metronidazole, miconazole, nifedipine, phenylbutazone, sulfonamides, trazodone, tricyclic antidepressants, and trimethoprim. Small changes in formulation (i.e., changes in brand) also may increase phenytoin levels or increase the risk of phenytoin toxicity.
- Drugs that may decrease phenytoin levels include bleomycin, carbamazepine, cisplatin, disulfiram, folic acid, intravenous fluids containing glucose, nitrofurantoin, oxacillin, rifampin, salicylates, and vinblastine.
- Primidone decreases the effectiveness of carbamazepine, ethosuximide, felbamate, lamotrigine, oral

anticoagulants, oxcarbazepine, topiramate, and valproate.

- Drugs that may increase valproic acid levels or increase risk of toxicity include dicumarol, phenylbutazone, and high doses of salicylate.
- Drugs that may decrease valproic acid levels include carbamazepine, phenobarbital, phenytoin, and primidone.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to monitor for therapeutic and toxic drug levels.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Consider recommended collection time in relation to dosing schedule. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection, noting the last dose of medication taken. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain to the patient the importance of following the medication regimen and instructions regarding drug interactions.

- ▶ Instruct the patient to immediately report any unusual sensations (e.g., ataxia, dizziness, dyspnea, lethargy, rash, tremors, mental changes, weakness, or visual disturbances) to his or her HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient to be prepared to provide the pharmacist with a list of other medications he or she is already taking in the event that the requesting HCP prescribes a medication.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, albumin, AST, bilirubin, BUN, creatinine, complete blood count, electrolytes, GGT, and protein blood total and fractions.
- ▶ See the Genitourinary and Hepatobiliary Systems tables at the back of the book for related tests by body system.

Antideoxyribonuclease-B, Streptococcal

SYNONYM/ACRONYM: ADNase-B, AntiDNase-B titer, antistreptococcal DNase-B titer, streptodornase.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Normal Results
Preschoolers	Less than 61 units
School-age children	Less than 171 units
Adults	Less than 86 units

DESCRIPTION: The presence of streptococcal deoxyribonuclease (DNase)-B antibodies is an indicator of recent infection, especially if a rise in antibody titer can be shown. This test is

more sensitive than the anti-streptolysin O test. A rise in titer of two or more dilution increments between acute and convalescent specimens is clinically significant.

INDICATIONS:

- Investigate the presence of streptococcal antibodies as a source of recent infection

RESULT:

Increased in:

- Presence of antibodies, especially a rise in titer, is indicative of exposure**
- Streptococcal infections (systemic)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- Inform the patient that the test is used to document recent streptococcal infection.
- Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- Obtain a history of the patient's immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- Review the procedure with the patient. Inform the patient that

specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Administer analgesics and antibiotics if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that a convalescent

specimen may be requested in 7 to 10 days. Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in

relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antibodies antistreptolysin O, culture throat, and group A streptococcal screen.
- See the Immune System table at the back of the book for related tests by body system.

Antidepressant Drugs (Cyclic): Amitriptyline, Nortriptyline, Doxepin, Imipramine, Desipramine

SYNONYM/ACRONYM: *Cyclic antidepressants: amitriptyline* (Elavil, Endep, Etrafon, Limbitrol DS, Triavil); *nortriptyline* (Aventyl HCL, Pamelor); *doxepin* (Adapin, Sinequan); *imipramine* (Anafranil, Clomipramine, Imavate, Presamine, Surmontil, Tofranil PM, Trimipramine); *desipramine* (Norpramin, pertofrane).

SPECIMEN: Serum (1 mL) collected in a red-top tube.

Drug	Route of Administration	Recommended Collection Time
Amitriptyline	Oral	Trough: immediately before next dose (at steady state)
Nortriptyline	Oral	Trough: immediately before next dose (at steady state)
Doxepin	Oral	Trough: immediately before next dose (at steady state)
Imipramine	Oral	Trough: immediately before next dose (at steady state)
Desipramine	Oral	Trough: immediately before next dose (at steady state)

REFERENCE VALUE: (Method: Chromatography for amitriptyline, nortriptyline, and doxepin; immunoassay for imipramine and desipramine)

Drug	Therapeutic Dose*	SI Units	Half-Life (h)	Volume of Distribution (L/kg)	Protein Binding (%)	Excretion
(SI = <i>Conventional Units</i> × 3.61)						
Amitriptyline, alone	80–200 ng/mL	289–722 nmol/L	17–40	10–36	85–95	Hepatic
(SI = <i>Conventional Units</i> × 3.8)						
Nortriptyline, alone	50–150 ng/mL	190–570 nmol/L	20–90	15–23	90–95	Hepatic
(SI = <i>Conventional Units</i> × 3.58)						
Combined doxepin and desmethyldoxepin	150–250 ng/mL	540–900 nmol/L	10–25	10–30	75–85	Hepatic
(SI = <i>Conventional Units</i> × 3.57)						
Imipramine	150–250 ng/mL	536–892 nmol/L	6–28	9–23	60–95	Hepatic
(<i>Conventional Units</i> × 3.75)						
Desipramine	150–250 ng/mL	562–938 nmol/L	6–28	9–23	60–95	Hepatic

*Conventional units.

DESCRIPTION: Cyclic antidepressants are used in the treatment of major depression. They have also been used effectively to treat bipolar disorder, panic disorder, attention-deficit hyperactivity disorder (ADHD), obsessive-compulsive disorder (OCD), enuresis, eating disorders (bulimia nervosa in particular), nicotine dependence (tobacco), and cocaine dependence. Numerous drug interactions occur with the cyclic antidepressants.

Many factors must be considered in effective dosing and monitoring of therapeutic drugs, including patient age, patient weight, interacting medications, electrolyte balance, protein levels, water balance, conditions that affect absorption and excretion, and foods, herbals, vitamins, and minerals that can either potentiate or inhibit the intended target concentration.

Trough collection times should be documented carefully in relation to the time of medication administration.

IMPORTANT NOTE: This information must be clearly and accurately communicated to avoid misunderstanding of the dose time in relation to the collection time. Miscommunication between the individual administering the medication and the individual collecting the specimen is the most frequent cause of subtherapeutic levels, toxic levels, and misleading information used in calculation of future doses.


INDICATIONS:

- Assist in the diagnosis and prevention of toxicity
- Evaluate overdose, especially in combination with ethanol (*Note:* Doxepin abuse is unusual)
- Monitor compliance with therapeutic regimen

RESULT:

Level	Response
Normal levels	Therapeutic effect
Subtherapeutic levels	Adjust dose as indicated
Toxic levels	Adjust dose as indicated
<i>Amitriptyline</i>	Hepatic impairment
<i>Nortriptyline</i>	Hepatic impairment
<i>Doxepin</i>	Hepatic impairment
<i>Imipramine</i>	Hepatic impairment
<i>Desipramine</i>	Hepatic impairment

CRITICAL VALUES:

 It is important to note the adverse effects of toxic and subtherapeutic levels of antidepressants. Care must be taken to investigate signs and symptoms of too little and too much medication. Note and immediately report to the health care practitioner any critically increased or subtherapeutic values and related symptoms.

Cyclic Antidepressants:

- Amitriptyline: Greater than 300 ng/mL
- Combined amitriptyline and nortriptyline: Greater than 250 ng/mL
- Combined doxepin and desmethyldoxepin: Greater than 150 ng/mL
- Desipramine: Greater than 300 ng/mL
- Imipramine: Greater than 250 ng/mL

Signs and symptoms of cyclic antidepressant toxicity include agitation, hallucinations, confusion, seizures, arrhythmias, hyperthermia, flushing, dilation of the pupils, and possible coma. Possible interventions include administration of activated charcoal; emesis; gastric lavage with saline; administration of physostigmine to counteract seizures, hypertension, or respiratory depression; administration of bicarbonate, propranolol, lidocaine, or phenytoin to counteract arrhythmias; and electrocardiographic monitoring.

INTERFERING FACTORS:

- Blood drawn in serum separator tubes (gel tubes).
- Contraindicated in patients with liver disease, and caution advised in patients with renal impairment.
- Cyclic antidepressants may potentiate the effects of oral anticoagulants.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to monitor for therapeutic and toxic drug levels.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Note the last time and dose of medication taken.

- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Consider recommended collection time in relation to dosing schedule. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection, noting the last dose of medication taken. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations* include the avoidance of alcohol consumption.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain to the patient the importance of following the medication regimen and instructions regarding drug interactions. Instruct the patient to immediately report any unusual sensations (e.g., severe headache, vomiting, sweating, visual disturbances) to his or

her HCP. Blood pressure should be monitored regularly. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Instruct the patient to be prepared to provide the pharmacist with a list of other medications he or she is already taking in the event that the requesting HCP prescribes a medication.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, albumin, AST, bilirubin, BUN, creatinine, complete blood count, electrolytes, GGT, and protein blood total and fractions.
- ▶ See the Genitourinary and Hepatobiliary Systems tables at the back of the book for related tests by body system.

Antidiuretic Hormone

SYNONYM/ACRONYM: Vasopressin, arginine vasopressin hormone, ADH.

SPECIMEN: Plasma (1 mL) collected in lavender-top (ethylenediaminetetraacetic acid [EDTA]) tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

RECOMMENDATION: This test should be ordered and interpreted with results of a serum osmolality.

Serum Osmolality*	Antidiuretic Hormone*	SI Units (Conventional Units × 0.926)
270–280 mOsm/kg	Less than 1.5 pg/mL	Less than 1.4 pmol/L
280–285 mOsm/kg	Less than 2.5 pg/mL	Less than 2.3 pmol/L
285–290 mOsm/kg	1–5 pg/mL	0.9–4.6 pmol/L
290–295 mOsm/kg	2–7 pg/mL	1.9–6.5 pmol/L
295–300 mOsm/kg	4–12 pg/mL	3.7–11.1 pmol/L

*Conventional units.

DESCRIPTION: Anti-diuretic hormone (ADH) is formed by the hypothalamus and stored in the posterior pituitary gland. ADH is released in response to increased serum osmolality or decreased blood volume. When the hormone is active, small amounts of concentrated urine are produced; in its absence, large amounts of dilute urine

are produced. Although a 1% change in serum osmolality stimulates ADH secretion, blood volume must decrease by approximately 10% for ADH secretion to be induced. Psychogenic stimuli, such as stress, pain, and anxiety, may also stimulate ADH release, but the mechanism is unclear.

INDICATIONS:

- Assist in the diagnosis of known or suspected malignancy associated with syndrome of inappropriate ADH secretion (SIADH), such as oat cell lung cancer, thymoma, lymphoma, leukemia, pancreatic carcinoma, prostate gland carcinoma, and intestinal carcinoma; elevated ADH levels indicate the presence of this syndrome
- Assist in the diagnosis of known or suspected pulmonary conditions associated with SIADH, such as tuberculosis, pneumonia, and positive-pressure mechanical ventilation
- Detect central nervous system trauma, surgery, or disease that may lead to impaired ADH secretion
- Differentiate neurogenic (central) diabetes insipidus from nephrogenic diabetes insipidus by decreased ADH levels in neurogenic diabetes insipidus or elevated levels in nephrogenic diabetes insipidus if normal feedback mechanisms are intact
- Evaluate polyuria or altered serum osmolality to identify possible alterations in ADH secretion as the cause

RESULT:**Increased in:**


- **Numerous conditions influence the release of ADH**
- Acute intermittent porphyria
- Brain tumor
- Disorders involving the central nervous system, thyroid gland, and adrenal gland
- Ectopic production (**systemic neoplasm**)
- Guillain-Barré syndrome
- Nephrogenic diabetes insipidus (**renal system does not respond to ADH stimulation**)
- Pain, stress, or exercise
- Pneumonia

- Pulmonary tuberculosis
- SIADH
- Tuberculous meningitis

Decreased in:

- **Decreased production or secretion of ADH in response to changes in blood volume or pressure**
- Nephrotic syndrome
- Pituitary (central) diabetes insipidus
- Psychogenic polydipsia

CRITICAL VALUES:

-  Effective treatment of SIADH depends on identifying and resolving the cause of increased ADH production. Signs and symptoms of SIADH are the same as those for hyponatremia, including irritability, tremors, muscle spasms, convulsions, and neurologic changes. The patient has enough sodium, but it is diluted in excess retained water.

INTERFERING FACTORS:

- Drugs that may increase ADH levels include barbiturates, carbamazepine, chlorpropamide, chlorthalidone, cisplatin, clofibrate, ether, furosemide, haloperidol, hydrochlorothiazide, lithium, methyclothiazide, narcotic analgesics, phenothiazides, polythiazide, tolbutamide, tricyclic antidepressants, vidarabine, vinblastine, and vincristine.
- Drugs that may decrease ADH levels include clonidine, demeclocycline, ethanol, lithium carbonate, and phenytoin.
- Recent radioactive scans or radiation within 1 week before the test can interfere with test results when radioimmunoassay is the test method.
- ADH exhibits diurnal variation, with highest levels of secretion occurring at night; first morning collection is recommended.

- ADH secretion is also affected by posture, with higher levels measured while upright.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of disorders affecting urine concentration.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ Prepare an ice slurry in a cup or plastic bag to have ready for immediate transport of the specimen to the laboratory. Prechill the lavender-top tube in the ice slurry.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. The patient should be encouraged to be calm and in a sitting position for specimen collection. Direct the patient to breathe

normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ The sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag. Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient, as appropriate, that treatment may include diuretic therapy and fluid restriction to successfully eliminate the excess water. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include BUN, chloride, osmolality, phosphorus, potassium, sodium, TSH, uric acid, and UA.
- ▶ See the Endocrine and Genitourinary System tables at the back of the book for related tests by body system.

Antipsychotic Drugs and Antimanic Drugs: Haloperidol, Lithium

SYNONYM/ACRONYM: *Antipsychotic drugs:* haloperidol (Haldol, Haldol Decanoate, Haldol Lactate); *antimanic drugs:* lithium (Eskalith, Eskalith-CR, Lithobid).

SPECIMEN: Serum (1 mL) collected in a red-top tube.

Drug	Route of Administration	Recommended Collection Time
Haloperidol	Oral	Peak: 3–6 hr
Lithium	Oral	Trough: at least 12 hr after last dose

REFERENCE VALUE: (Method: Chromatography for haloperidol; ion-selective electrode for lithium)

Drug	Therapeutic Dose*	SI Units	Half-Life (h)	Volume of Distribution (L/kg)	Protein Binding (%)	Excretion
<i>(SI = Conventional Units × 2.66)</i>						
Haloperidol	4–26 ng/mL	11–69 nmo/L	15–40	18–30	90	Hepatic
<i>(SI = Conventional Units × 1)</i>						
Lithium	0.6–1.4 mEq/L	0.6–1.4 mmol/L	18–24	0.7–1.0	0	Renal

*Conventional units.

DESCRIPTION: Haloperidol is an antipsychotic tranquilizer used for treatment of acute and chronic psychotic disorders, Tourette's syndrome, and hyperactive children with severe behavioral problems. Frequent monitoring is important due to the unstable relationship between dosage and circulating steady-state concentration. Lithium is used in the treatment

of manic depression. Daily monitoring of lithium levels is important until the proper dosage is achieved. Lithium is cleared and reabsorbed by the kidney. Clearance is increased when sodium levels are increased and decreased in conditions associated with low sodium levels, therefore patients receiving lithium therapy should try to maintain a balanced daily

intake of sodium. Lithium levels affect other organ systems. There is a high incidence of pulmonary complications associated with lithium toxicity. Lithium can also affect cardiac conduction, producing T-wave depressions. These ECG changes are usually insignificant and reversible, and are seen in 10% to 20% of patients on lithium therapy. Chronic lithium therapy has been shown to result in enlargement of the thyroid gland in a small percentage of patients.

Many factors must be considered in effective dosing and monitoring of therapeutic drugs, including patient age, patient weight, interacting medications, electrolyte balance, protein levels, water balance, conditions that affect absorption and excretion, and foods, herbals, vitamins, and minerals that can either potentiate or inhibit the

intended target concentration. Peak collection times should be documented carefully in relation to the time of medication administration.

IMPORTANT NOTE: This information must be clearly and accurately communicated to avoid misunderstanding of the dose time in relation to the collection time. Miscommunication between the individual administering the medication and the individual collecting the specimen is the most frequent cause of subtherapeutic levels, toxic levels, and misleading information used in calculation of future doses.


INDICATIONS:

- Assist in the diagnosis and prevention of toxicity
- Monitor compliance with therapeutic regimen

RESULT:

Level	Response
Normal levels	Therapeutic effect
Subtherapeutic levels	Adjust dose as indicated
Toxic levels	Adjust dose as indicated
<i>Haloperidol</i>	Hepatic impairment
<i>Lithium</i>	Renal impairment

CRITICAL VALUES:

 It is important to note the adverse effects of toxic and subtherapeutic levels. Care must be taken to investigate signs and symptoms of not enough medication and too much medication. Note and immediately report to the health care provider (HCP) any critically increased or subtherapeutic values and related symptoms.

Haloperidol: Greater Than 50 ng/mL

Signs and symptoms of haloperidol toxicity include hypotension, myocardial depression, respiratory depression, and extrapyramidal neuromuscular reactions. Possible interventions include emesis (contraindicated in the absence of gag reflex or central nervous system depression or excitation), and gastric

lavage followed by administration of activated charcoal.

Lithium: Greater Than 1.5 mEq/L

Signs and symptoms of lithium toxicity include ataxia, coarse tremors, muscle weakness, vomiting, diarrhea, confusion, convulsions, stupor, T-wave flattening, loss of consciousness, and possible coma. Possible interventions include administration of activated charcoal, gastric lavage, and administration of intravenous fluids with diuresis.

INTERFERING FACTORS:

- Blood drawn in serum separator tubes (gel tubes).
- Contraindicated in patients with liver disease, and caution advised in patients with renal impairment.
- Haloperidol may increase levels of tricyclic antidepressants and increase the risk of lithium toxicity.
- Drugs that may increase lithium levels include angiotensin-converting enzyme inhibitors, some NSAIDs, and thiazide diuretics.
- Drugs and substances that may decrease lithium levels include acetazolamide, osmotic diuretics, theophylline, and caffeine.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to monitor for therapeutic and toxic drug levels.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Consider recommended collection time in relation to dosing schedule. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection, noting the last dose of medication taken. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations** include the avoidance of alcohol consumption.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain to the patient the importance of following the medication regimen and instructions regarding drug interactions.
- ▶ Instruct the patient receiving haloperidol to immediately report any unusual symptoms (e.g., arrhythmias, blurred vision, dry eyes, repetitive uncontrolled movements) to his or her HCP. Instruct the patient receiving lithium to immediately report any unusual symptoms (e.g., anorexia, nausea, vomiting, diarrhea, dizziness, drowsiness, dysarthria, tremor, muscle twitching, visual disturbances) to his or her HCP.

Answer any questions or address any concerns voiced by the patient or family.

- ▶ Instruct the patient to be prepared to provide the pharmacist with a list of other medications he or she is already taking in the event that the requesting HCP prescribes a medication.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related laboratory tests include albumin, BUN, calcium, creatinine, glucose, magnesium, osmolality, potassium, sodium, T_4 , and TSH.
- ▶ See the Genitourinary and Hepatobiliary System tables in the back of the book for related tests by body system.

Antithrombin III

SYNONYM/ACRONYM: Heparin cofactor assay, AT-III.

SPECIMEN: Plasma (1 mL) collected in a blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

	Conventional Units	(SI = Conventional Units × 10)
Immunologic assay	21–30 mg/dL	210–300 mg/L
	Conventional Units	(SI = Conventional Units × 10)
Functional assay, Age 6 mo–Adult	85–115% of standard	0.85–1.15
Neonate	39–87% of standard	0.39–0.87

DESCRIPTION: Antithrombin III (AT-III) can inhibit thrombin and factors IX, X, XI, and XII. It is a heparin cofactor, interacting with heparin and thrombin. AT-III acts to increase the rate at which thrombin is neutralized or inhibited, and it decreases the total quantity of thrombin inhibited. Patients with low levels of AT-III show some level of resistance to heparin therapy and are at risk for venous thrombosis.

INDICATIONS:

- Investigate tendency for thrombosis

RESULT:

Increased in:

- Acute hepatitis following renal transplantation
- Renal transplantation
- Vitamin K deficiency (*decreased consumption due to impaired coagulation factor function*)

Decreased in:

- Carcinoma
- Chronic liver failure (*decreased synthesis*)
- Cirrhosis (*decreased synthesis*)
- Congenital deficiency
- Disseminated intravascular coagulation (*increased consumption*)
- Liver transplantation or partial hepatectomy (*decreased synthesis*)
- Nephrotic syndrome (*increased loss*)
- Pulmonary embolism (*increased consumption*)
- Venous thrombosis (*increased consumption*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase AT-III levels include anabolic steroids,

gemfibrozil, and warfarin (coumadin).

- Drugs that may decrease AT-III levels include asparaginase, estrogens, heparin, and oral contraceptives.
- Placement of the tourniquet for longer than 1 min can result in venous stasis and changes in the concentration of the plasma proteins to be measured. Platelet activation may also occur under these conditions, resulting in erroneous measurements.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of coagulation disorders.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
 - ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
 - ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture
- Important note:* Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/ NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range. When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with tissue thromboplastin.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed samples stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies cardiolipin, echocardiography, lung perfusion scan, aPTT, protein C, protein S, venography lower extremities, and vitamin K.
- ▶ See the Hematopoietic System table at the back of the book for related tests by body system.

α_1 -Antitrypsin and α_1 -Antitrypsin Phenotyping

SYNONYM/ACRONYM: α_1 -antitrypsin: A₁AT, α_1 -AT, AAT; α_1 -antitrypsin phenotyping: A₁AT phenotype, α_1 -AT phenotype, AAT phenotype, Pi phenotype.

SPECIMEN: Serum (1 mL) for α_1 -antitrypsin (α_1 -AT) and serum (2 mL) for α_1 -AT phenotyping collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Rate nephelometry for α_1 -AT, isoelectric focusing/high-resolution electrophoresis for α_1 -AT phenotyping)

α_1 -Antitrypsin

Age	Conventional Units	SI Units (Conventional Units \times 0.01)
0–1 mo	124–348 mg/dL	1.24–3.48 g/L
2–6 mo	111–297 mg/dL	1.11–2.97 g/L
7 mo–2 yr	95–251 mg/dL	0.95–2.51 g/L
3–19 yr	110–279 mg/dL	1.10–2.79 g/L
Adult	126–226 mg/dL	1.26–2.26 g/L

α_1 -Antitrypsin Phenotyping

There are three major protease inhibitor phenotypes:

- MM—Normal
- SS—Intermediate; heterozygous
- ZZ—Markedly abnormal; homozygous

The total level of measurable α_1 -AT varies with genotype. The effects of α_1 -AT deficiency depend on the patient's personal habits, but are most severe in patients who smoke tobacco.

DESCRIPTION: α_1 -AT is the main glycoprotein produced by the liver. Its inhibitory function is directed against proteolytic enzymes, such as trypsin, elastin, and plasmin, released by alveolar macrophages and bacteria. In the absence of α_1 -AT, functional tissue is destroyed by proteolytic enzymes and replaced with excessive connective tissue. Emphysema develops at an earlier age in α_1 -AT-deficient emphysema patients than in other emphysema patients. α_1 -AT deficiency is passed on as an autosomal recessive trait. Inherited deficiencies are associated early in life with development of lung and liver disorders. In the pediatric population, the

ZZ phenotype usually presents as liver disease, cholestasis, and cirrhosis. Greater than 80% of ZZ-deficient individuals ultimately develop chronic lung or liver disease. It is important to identify inherited deficiencies early in life. Typically, α_1 -AT-deficient patients have circulating levels less than 50 mg/dL. Patients who have α_1 -AT values less than 140 mg/dL should be phenotyped.

Elevated levels are found in normal individuals when an inflammatory process, such as rheumatoid arthritis, bacterial infection, neoplasm, or vasculitis, is present. Decreased levels are found in affected patients with chronic obstructive pulmonary disease (COPD) and in children with cirrhosis of the liver. Deficiency of this enzyme is the most common cause of liver disease in the pediatric population. Decreased α_1 -AT levels also may be elevated into the normal range in heterozygous α_1 -AT-deficient patients during concurrent infection, pregnancy, estrogen therapy, steroid therapy, cancer, and postoperative periods. Homozygous α_1 -AT-deficient patients do not show such an elevation.

INDICATIONS:

- Assist in establishing a diagnosis of COPD
- Assist in establishing a diagnosis of liver disease
- Detect hereditary absence or deficiency of α_1 -AT

RESULT:**Increased in:****Increases are rapid and nonspecific in response to inflammation**

- Acute and chronic inflammatory conditions
- Carcinomas
- Estrogen therapy
- Postoperative recovery
- Pregnancy
- Steroid therapy
- Stress (extreme physical)

Decreased in:**Liver disease affects synthesis of this protein**

- COPD
- Homozygous α_1 -AT-deficient patients
- Liver disease (severe)
- Liver cirrhosis (child)
- Malnutrition
- Nephrotic syndrome

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- α_1 -AT is an acute-phase reactant protein, and any inflammatory process elevates levels. If a serum C-reactive protein is performed simultaneously and is positive, the patient should be retested for α_1 -AT in 10 to 14 days.
- Rheumatoid factor causes false-positive elevations.
- Drugs that may increase serum α_1 -AT levels include aminocaproic acid, estrogen therapy, oral contraceptives (high-dose preparations), oxymetholone, streptokinase, tamoxifen, and typhoid vaccine.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify COPD and liver disease associated with α_1 -antitrypsin deficiency.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary and respiratory system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Oral contraceptives should be withheld 24 hr before the specimen is collected, although this restriction should first be confirmed with the health care provider (HCP) ordering the test.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient

demographics, date, and time of collection. Perform a venipuncture.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medication as directed by the HCP.
- ▶ **Nutritional considerations:** Malnutrition is commonly seen in α_1 -AT-deficient patients with severe respiratory disease for many reasons, including fatigue, lack of appetite, and gastrointestinal distress. Research has estimated that the daily caloric intake required for respiration in patients with COPD is 10 times higher than that required of normal individuals. Inadequate nutrition can result in hypophosphatemia, especially in the respirator-dependent patient. During periods of starvation, phosphorus leaves the intracellular space and moves outside the tissue, resulting in dangerously decreased phosphorus levels. Adequate intake of vitamins A and C is important to prevent pulmonary infection and to decrease the extent of lung tissue damage. The importance of following the prescribed diet should be stressed to the patient and caregiver.
- ▶ **Nutritional considerations:** Water balance must be closely monitored in α_1 -AT-deficient patients with COPD. Fluid retention can lead to pulmonary edema.
- ▶ Educate the patient with abnormal findings in preventive measures for protection of the lungs (e.g., avoid contact with persons who have respiratory or other infections; avoid the use of tobacco; avoid areas having highly polluted air; and avoid work environments with hazards such as fumes, dust, and other respiratory pollutants).
- ▶ Instruct the affected patient in deep breathing and pursed-lip breathing to enhance breathing patterns as appropriate. Inform the patient of

smoking cessation programs, as appropriate.

- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Because decreased α_1 -AT can be an inherited disorder, it may be appropriate to recommend resources for genetic counseling if levels less than 140 mg/dL are reported. It may also be appropriate to inform the patient that α_1 -AT phenotype testing can be performed on family members to determine the homozygous or heterozygous nature of the deficiency.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of the importance of medical follow-up, and suggest ongoing support resources to assist the patient in coping with chronic illness and possible early death. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACE, anion gap, arterial/alveolar oxygen ratio, biopsy lung, blood gases, blood pool imaging, bronchoscopy, electrolytes, lung perfusion scan, lung ventilation scan, osmolality, PET heart, phosphorus, PFTs, plethysmography, and pulse oximetry, if COPD is suspected. ALT, albumin, ALP, ammonia, bilirubin and fractions, biopsy liver, cholangiography percutaneous transhepatic, cholangiography post-op, CT biliary tract and liver, ERCP, GGT, hepatobiliary scan, liver and spleen scan, protein and fractions, PT/INR, and US liver, if liver disease is suspected.
- ▶ See the Hepatobiliary and Respiratory System tables at the back of the book for related tests by body system.

A Apolipoprotein A and B

SYNONYM/ACRONYM: Apo A and Apo B.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunonephelometry)

Apolipoprotein A

Age	Conventional Units	SI Units (Conventional Units × 0.01)
Male		
<i>Newborn</i>	41–93 mg/dL	0.41–0.93 g/L
6 mo–4 yr	67–163 mg/dL	0.67–1.63 g/L
<i>Adult</i>	81–166 mg/dL	0.81–1.66 g/L
Female		
<i>Newborn</i>	38–106 mg/dL	0.38–1.06 g/L
6 mo–4 yr	60–148 mg/dL	0.60–1.48 g/L
<i>Adult</i>	80–214 mg/dL	0.80–2.14 g/L

Apolipoprotein B

Age	Conventional Units	SI Units (Conventional Units × 0.01)
Newborn–5 yr	11–31 mg/dL	0.11–0.31 g/L
5–17 yr		
<i>Male</i>	47–139 mg/dL	0.47–1.39 g/L
<i>Female</i>	41–96 mg/dL	0.41–0.96 g/L
<i>Adult</i>		
<i>Male</i>	46–174 mg/dL	0.46–1.74 g/L
<i>Female</i>	46–142 mg/dL	0.46–1.42 g/L

DESCRIPTION: Apolipoproteins assist in the regulation of lipid metabolism by activating and inhibiting enzymes required for this process. The apolipoproteins also help keep lipids in solution as they circulate in the blood and direct the lipids toward the correct target organs and tissues in the body. Apolipoprotein A (Apo A), the major component of

high-density lipoprotein (HDL), is synthesized in the liver and intestines. Apo A-I activates the enzyme lecithin-cholesterol acyl-transferase (LCAT), whereas Apo A-II inhibits LCAT. It is believed that Apo A measurements may be more important than HDL cholesterol measurements as a predictor of coronary artery disease (CAD). There is an inverse relationship

between Apo A levels and risk for developing CAD. Because of difficulties with method standardization, the above-listed reference ranges should be used as a rough guide in assessing abnormal conditions. Values for African Americans are 5 to 10 mg/dL higher than values for whites. Apolipoprotein B (Apo B), the major component of the low-density lipoproteins (chylomicrons, LDL, and very-low-density lipoprotein), is synthesized in the liver and intestines.

INDICATIONS:

- Evaluation for risk of CAD

RESULT:

The exact functional role of apolipoproteins is unclear but there is a very strong association between Apo A and HDL “good” cholesterol and Apo B and LDL “bad” cholesterol

Apolipoprotein A

Increased in:

- Familial hyper- α -lipoproteinemia
- Weight reduction

Decreased in:

- Abetalipoproteinemia
- Cholestasis
- Chronic renal failure
- Diabetes (uncontrolled)
- Diet high in carbohydrates or polyunsaturated fats
- Familial deficiencies of related enzymes and lipoproteins
- Hepatocellular disorders
- Hypertriglyceridemia
- Nephrotic syndrome
- Premature coronary heart disease
- Smoking

Apolipoprotein B

Increased in:

- Anorexia nervosa
- Cushing's syndrome

- Diabetes
- Dysglobulinemia
- Emotional stress
- Hepatic disease
- Hepatic obstruction
- Hyperlipoproteinemias
- Hypothyroidism
- Infantile hypercalcemia
- Nephrotic syndrome
- Porphyria
- Pregnancy
- Premature CAD
- Renal failure
- Werner's syndrome

Decreased in:

- Acute stress (burns, illness)
- Chronic anemias
- Chronic pulmonary disease
- Familial deficiencies of related enzymes and lipoproteins
- Hyperthyroidism
- Inflammatory joint disease
- Intestinal malabsorption
- α -Lipoprotein deficiency (Tangier disease)
- Malnutrition
- Myeloma
- Reye's syndrome
- Weight reduction

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may increase Apo A levels include anti-convulsants, beclorate, bezafibrate, ciprofibrate, estrogens, furosemide, lovastatin, pravastatin, prednisolone, simvastatin, and ethanol (abuse).
- Drugs that may decrease Apo A levels include androgens, β -blockers, diuretics, and probucol.
- Drugs that may increase Apo B levels include amiodarone, androgens, β -blockers, catecholamines, cyclosporine, diuretics, ethanol (abuse), etretinate, glucogenic corticosteroids, oral contraceptives, and phenobarbital.
- Drugs that may decrease Apo B levels include beclorate,

captopril, cholestyramine, fibrates, ketanserin, lovastatin, niacin, nifedipine, pravastatin, prazosin, probucol, and simvastatin.

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess and monitor risk for coronary artery disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medication, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ The patient should abstain from food for 6 to 12 hr before specimen collection.
- ▶ There are no fluid or medication restrictions unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary or activity restrictions, and pretesting preparations; assure that food has been restricted for at least 6 to 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ Instruct the patient to resume usual diet as directed by the health care provider (HCP).
- ▶ *Nutritional considerations:* Decreased Apo A and/or increased Apo B levels may be associated with CAD. Nutritional therapy is recommended for individuals identified to be at high risk for developing CAD. Overweight patients should be encouraged to achieve a normal weight. The American Heart Association Step 1 and Step 2 diets may be helpful in achieving a goal of reducing total cholesterol and triglyceride levels. The Step 1 diet emphasizes a reduction in foods high in saturated fats and cholesterol. Red meats, eggs, and dairy products are the major sources of saturated fats and cholesterol. If triglycerides are also elevated, the patient should be advised to eliminate or reduce alcohol and simple carbohydrates from the diet. The Step 2 diet recommends stricter reductions.
- ▶ A written report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as

appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Heart Association (www.americanheart.org).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, AST, ANP, BNP, blood gases, CRP, calcium and ionized calcium, cholesterol (total, HDL, and LDL), CK and isoenzymes, CT scoring, echocardiography, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI chest, myocardial infarct scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, triglycerides, and troponin.
- ▶ See the Cardiovascular System table at the back of the book for related tests by body system.

Arthrogram

SYNONYM/ACRONYM: Joint study.

AREA OF APPLICATION: Shoulder, elbow, wrist, hip, knee, ankle, temporomandibular joint.

CONTRAST: Iodinated or gadolinium.

DESCRIPTION: An arthrogram evaluates the cartilage, ligaments, and bony structures that compose a joint. After local anesthesia is administered to the area of interest, a fluoroscopically guided small-gauge needle is inserted into the joint space. Fluid in the joint space is aspirated and sent to the laboratory for analysis. Contrast medium is inserted into the joint space to outline the soft tissue structures and the contour of the joint. After brief exercise of the joint, radiographs or magnetic resonance images (MRIs) are obtained. Arthrograms are used primarily for assessment of persistent, unexplained joint discomfort.

INDICATIONS:

- Evaluate pain, swelling, or dysfunction of a joint
- Monitor disease progression

RESULT:

Normal findings in:

- Normal bursae, menisci, ligaments, and articular cartilage of the joint (*note:* the cartilaginous surfaces and menisci should be smooth, without evidence of erosion, tears, or disintegration)

Abnormal findings in:




- Arthritis
- Cysts
- Diseases of the cartilage (chondromalacia)
- Injury to the ligaments

- Joint derangement
- Meniscal tears or laceration
- Muscle tears
- Osteochondral fractures
- Osteochondritis dissecans
- Synovial tumor
- Synovitis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shell fish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of a nonionic contrast medium.
- Patients with metal in their body, such as shrapnel or ferrous metal in the eye.
-  Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI.
-  Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73 m²). Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
- Patients with bleeding disorders, active arthritis, or joint infections.

Factors that may impair clear imaging:

- Metallic objects within the examination field which may inhibit organ visualization and can produce unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the examination room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure assesses the joint being examined.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics and dyes.
- ◆ Obtain a history of results of the patient's musculoskeletal system, symptoms, and previously performed laboratory tests and diagnostic and surgical procedures. Ensure that the results of blood tests are obtained and recorded before the procedure, especially coagulation tests, BUN, and creatinine, if

contrast medium is to be used. Obtain a history of renal dysfunction if the use of GBCA is anticipated.

- ▶ Ensure the results of BUN, creatinine and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in the radiology department by a HCP and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.

- ▶ Observe standard precautions and follow the general guidelines in Appendix A. Instruct the patient to cooperate fully and to follow directions.
- ▶ Place the patient on the table in a supine position.
- ▶ The skin surrounding the joint is aseptically cleaned and anesthetized.
- ▶ A small-gauge needle is inserted into the joint space.
- ▶ Any fluid in the space is aspirated and sent to the laboratory for analysis.
- ▶ Contrast medium is inserted into the joint space with fluoroscopic guidance.
- ▶ The needle is removed, and the joint is exercised to help distribute the contrast medium.
- ▶ X-rays or MRIs are taken of the joint.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ During x-ray imaging, lead protection is placed over the gonads to prevent their irradiation.
- ▶ If MRI images are taken, supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Assess the joint for swelling after the test. Apply ice as needed.
- ▶ Instruct the patient to use a mild analgesic (aspirin, acetaminophen), as ordered, if there is discomfort.
- ▶ Advise the patient to avoid strenuous activity until approved by the HCP.
- ▶ Instruct the patient to notify the HCP if fever, increased pain, drainage, warmth, edema, or swelling of the joint occurs.
- ▶ Inform the patient that noises from the joint after the procedure are common and should disappear 24 to 48 hr after the procedure.
- ▶ Recognize anxiety related to test results. Discuss the implications of

abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate

test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies anticyclic citrullinated peptide, ANA, arthroscopy, BMD, bone scan, BUN, CRP, creatinine, ESR, MRI musculoskeletal, PT/INR, radiography bone, RF, synovial fluid analysis, and uric acid.
- ▶ Refer to the Musculoskeletal System table at the back of the book for related tests by body system.

Arthroscopy

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Joints.

CONTRAST: None.

DESCRIPTION: Arthroscopy provides direct visualization of a joint through the use of a fiberoptic endoscope. The arthroscope has a light, fiberoptics, and lenses; it connects to a monitor, and the images are recorded for future study and comparison. This procedure is used for inspection of joint structures, performance of a biopsy, and surgical repairs to the joint. Meniscus removal, spur removal, and ligamentous repair are some of the surgical procedures that may be performed. This procedure is most commonly performed to diagnose athletic injuries and acute or chronic joint disorders. Because arthroscopy

allows direct visualization, degenerative processes can be accurately differentiated from injuries. A local anesthetic allows the arthroscope to be inserted through the skin with minimal discomfort. This procedure may also be done under a spinal or general anesthetic, especially if surgery is anticipated.

INDICATIONS:

- Detect torn ligament or tendon
- Evaluate joint pain and damaged cartilage
- Evaluate meniscal, patellar, condylar, extrasynovial, and synovial injuries or diseases of the knee

- Evaluate the extent of arthritis
- Evaluate the presence of gout
- Monitor effectiveness of therapy
- Remove loose objects

RESULT:

Normal findings in:

- Normal muscle, ligament, cartilage, synovial, and tendon structures of the joint

Abnormal findings in:

- Arthritis
- Chondromalacia
- Cysts
- Degenerative joint changes
- Ganglion or Baker's cyst
- Gout or pseudogout
- Joint tumors
- Loose bodies
- Meniscal disease
- Osteoarthritis
- Osteochondritis
- Rheumatoid arthritis
- Subluxation, fracture, or dislocation
- Synovitis
- Torn cartilage
- Torn ligament
- Torn rotator cuff
- Trapped synovium

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with bleeding disorders, active arthritis, or cardiac conditions
- Patients with joint infection or skin infection near proposed arthroscopic site
- Patients who have had an arthrogram within the last 14 days

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

- Fibrous ankylosis of the joint preventing effective use of the arthroscope
- Joints with flexion of less than 50°

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the joint to be examined.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex and anesthetics.
- ▶ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that some discomfort and pain may be experienced during the test. Inform the patient that the procedure is performed by a HCP, usually in the radiology department, and takes approximately 30 to 60 min.

- ▶ Explain that a preprocedure sedative may be administered to promote relaxation, as ordered.
- ▶ Crutch walking should be taught before the procedure if it is anticipated postoperatively.
- ▶ The joint area and areas 5 to 6 in. above and below the joint are shaved and prepared for the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to refrain from food and fluids for 6 to 8 hr before the test. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with food and fluid restrictions for at least 6 to 8 hr prior to the procedure.
- ▶ Resuscitation equipment and patient monitoring equipment must be available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ The extremity is scrubbed, elevated, and wrapped with an elastic bandage from the distal portion of the extremity to the proximal portion to drain as much blood from the limb as possible.
- ▶ A pneumatic tourniquet placed around the proximal portion of the limb is inflated, and the elastic bandage is removed.
- ▶ As an alternative to a tourniquet, a mixture of lidocaine with epinephrine and sterile normal saline may be instilled into the joint to help reduce bleeding.
- ▶ The joint is placed in a 45° angle, and a local anesthetic is administered.
- ▶ A small incision is made in the skin in the lateral or medial aspect of the joint.
- ▶ The arthroscope is inserted into the joint spaces. The joint is manipulated as it is visualized. Added puncture sites may be needed to provide a full view of the joint.
- ▶ Biopsy or treatment can be performed at this time, and photographs should be taken for future reference.
- ▶ After inspection, specimens may be obtained for cytologic and microbiologic study. All specimens are placed in appropriate containers, labeled with the corresponding patient demographics, date and time of collection, site location, and promptly sent to the laboratory.
- ▶ The joint is irrigated, and the arthroscope is removed. Manual pressure is applied to the joint to remove remaining irrigation solution.
- ▶ The incision sites are sutured, and a pressure dressing is applied.
- ▶ Sterile gloves and gowns are worn throughout the procedure.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Advise the patient to avoid strenuous activity involving the joint until approved by the HCP.
- ▶ Instruct the patient to resume normal diet and medications, as directed by the HCP.
- ▶ Monitor the patient's circulation and sensations in the joint area.
- ▶ Instruct the patient to immediately report symptoms such as fever, excessive bleeding, difficulty breathing, incision site redness, swelling, and tenderness.
- ▶ Instruct the patient to elevate the joint when sitting and to avoid overbending of the joint to reduce swelling.
- ▶ Instruct the patient to take an analgesic for joint discomfort after the procedure; ice bags may be used to reduce postprocedure swelling.
- ▶ Inform the patient to shower after 48 hr but to avoid a tub bath until after his or her appointment with the HCP.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing,

treatment or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family. Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include anti-cyclic citrullinated peptide, ANA, arthrogram, BMD, bone scan, CRP, ESR, MRI musculoskeletal, radiography of the bone, RF, synovial fluid analysis, and uric acid.
- Refer to the Musculoskeletal System table at the back of the book for related tests by body system.

A

Aspartate Aminotransferase

SYNONYM/ACRONYM: Serum glutamic-oxaloacetic transaminase, AST, SGOT.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Spectrophotometry, enzymatic at 37°C)

Age	Conventional & SI Units
Newborn	47–150 units/L
10 d–23 mo	9–80 units/L
2–59 yr	
<i>Male</i>	15–40 units/L
<i>Female</i>	13–35 units/L
60–90 yr	
<i>Male</i>	19–48 units/L
<i>Female</i>	9–36 units/L

DESCRIPTION: Aspartate aminotransferase (AST) is an enzyme that catalyzes the reversible transfer of an amino group between aspartate and α -ketoglutaric acid. It was formerly known as serum glutamic-oxaloacetic transaminase (SGOT). AST exists in large amounts in liver and myocardial cells and in smaller but significant amounts

in skeletal muscle, kidneys, pancreas, and the brain. Serum AST rises when there is cellular damage to the tissues where the enzyme is found. AST values greater than 500 units/L are usually associated with hepatitis and other hepatocellular diseases in an acute phase. AST levels are very elevated at birth and decrease with age. *Note:* Measurement of AST in evaluation of myocardial infarction has been replaced by more sensitive tests, such as creatine kinase–MB fraction (CK-MB) and troponin.

INDICATIONS:

- Assist in the diagnosis of disorders or injuries involving the tissues where AST is normally found

- Assist (formerly) in the diagnosis of myocardial infarction (*Note:* AST rises within 6 to 8 hr, peaks at 24 to 48 hr, and declines to normal within 72 to 96 hr of a myocardial infarction)
- Compare serially with alanine aminotransferase levels to track the course of hepatitis
- Monitor response to therapy with potentially hepatotoxic or nephrotoxic drugs
- Monitor response to treatment for various disorders in which AST may be elevated, with tissue repair indicated by declining levels

RESULT:

AST is released from any damaged cell in which it is stored so conditions that affect the liver, kidneys, heart, or skeletal muscle and cause cellular destruction demonstrate elevated AST levels.

Significantly increased in (greater than five times normal levels):

- Acute hepatitis
- Acute hepatocellular disease
- Acute pancreatitis
- Shock

Moderately increased in (three to five times normal levels):

- Biliary tract obstruction
- Cardiac arrhythmias
- Chronic hepatitis
- Congestive heart failure
- Dermatomyositis
- Liver tumors
- Muscular dystrophy

Slightly increased in (two to three times normal):

- Cerebrovascular accident
- Cirrhosis, fatty liver
- Delirium tremens
- Hemolytic anemia
- Pericarditis
- Pulmonary infarction

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase AST levels by causing cholestasis include amitriptyline, anabolic steroids, androgens, benzodiazepines, chlorothiazide, chlorpropamide, dapsone, erythromycin, estrogens, ethionamide, gold salts, imipramine, mercaptopurine, nitrofurans, oral contraceptives, penicillins, phenothiazines, progesterone, propoxyphene, sulfonamides, tamoxifen, and tolbutamide.
- Drugs that may increase AST levels by causing hepatocellular damage include acetaminophen (toxic), acetylsalicylic acid, allopurinol, amiodarone, anabolic steroids, anticonvulsants, asparaginase, azithromycin, bromocriptine, captopril, cephalosporins, chloramphenicol, clindamycin, clofibrate, danazol, enflurane, ethambutol, ethionamide, fenofibrate, fluconazole, fluoroquinolones, foscarnet, gentamicin, indomethacin, interferon, interleukin-2, levamisole, levodopa, lincomycin, low-molecular-weight heparin, methyl dopa, monoamine oxidase inhibitors, naproxen, nifedipine, nitrofurans, oral contraceptives, probenecid, procainamide, quinine, ranitidine, retinol, ritodrine, sulfonylureas, tetracyclines, tobramycin, and verapamil.
- Hemolysis falsely increases AST values.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is primarily used to assess liver function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
 - ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
 - ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
 - ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Increased AST levels may be associated with liver disease. Dietary recommendations may be indicated and will vary depending on the condition and its severity. Currently, there are no specific medications that can be given to cure hepatitis, but elimination of alcohol ingestion and a diet optimized for convalescence are commonly included in the treatment plan. A high-calorie, high-protein, moderate-fat diet with a high fluid intake is often recommended for patients with hepatitis. Treatment of cirrhosis is different; a low-protein diet may be in order if the patient's liver can no longer process the end products of protein metabolism. A diet of soft foods may be required if esophageal varices have developed. Ammonia levels may be used to determine whether protein should be added to or reduced from the diet. Patients should be encouraged to eat simple carbohydrates and emulsified fats (as in homogenized milk or eggs), as opposed to complex carbohydrates (e.g., starch, fiber, and glycogen [animal carbohydrates]) and complex fats, which require additional bile to emulsify them so that they can be used. The cirrhotic patient should be observed carefully for the development of ascites, in which case fluid and electrolyte balance requires strict attention.
- ▶ **Nutritional considerations:** Increased AST levels may be associated with coronary artery disease (CAD). Nutritional therapy is recommended for individuals identified to be at high risk for CAD. Overweight patients should be encouraged to achieve a normal weight. The American Heart Association Step 1 and Step 2 diets may be helpful in achieving a

goal of reducing total cholesterol and triglyceride levels. The Step 1 diet emphasizes a reduction in foods high in saturated fats and cholesterol. Red meats, eggs, and dairy products are the major sources of saturated fats and cholesterol. If triglycerides are also elevated, the patient should be advised to eliminate or reduce alcohol and simple carbohydrates from the diet. The Step 2 diet recommends stricter reductions.

- ▶ Instruct the patient to immediately report chest pain and changes in breathing pattern to the HCP.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include acetaminophen, ALT, albumin, ALP, ammonia, AMA/ASMA, α_1 -antitrypsin/phenotyping, bilirubin and fractions, biopsy liver, cholangiography percutaneous transhepatic, cholangiography post-op, CT biliary tract and liver, ERCP, ethanol, ferritin, GGT, hepatitis antigens and antibodies, hepatobiliary scan, iron/total iron-binding capacity, liver and spleen scan, protein and fractions, PT/INR, and US liver, if liver disease is suspected; and antiarrhythmic drugs, apolipoprotein A and B, ANP, BNP, blood gases, CRP, calcium/ionized calcium, CT scoring, cholesterol (total, HDL, and LDL), CK, echocardiography, Holter monitor, homocysteine, LDH, MRI chest, myocardial infarct scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, triglycerides, and troponin if myocardial infarction is suspected.
- ▶ See the Cardiovascular and Hepatobiliary System tables in the back of the book for related tests by body system.

Atrial Natriuretic Peptide

SYNONYM/ACRONYM: Atrial natriuretic hormone, atrial natriuretic factor, ANF, ANH.

SPECIMEN: Plasma (1 mL) collected in a chilled, lavender-top tube. Specimen should be transported tightly capped and in an ice slurry.

REFERENCE VALUE: (Method: Radioimmunoassay)

Conventional Units

(SI = Conventional Units \times 2.66)

20–77 pg/mL

20–77 ng/L

RESULT:**Increased in:**

ANP is secreted in response to increased hemodynamic load caused by physiologic stimuli as with atrial stretch or endocrine stimuli from the aldosterone/renin system

- Asymptomatic cardiac volume overload
- CHF
- Elevated cardiac filling pressure
- Paroxysmal atrial tachycardia

Decreased in: N/A

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Audiometry, Hearing Loss

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Ears.

CONTRAST: N/A.

DESCRIPTION: Tests to estimate hearing ability can be performed on patients of any age, e.g., at birth before discharge from a hospital or birthing center, as part of a school screening program, or as adults if indicated. Hearing loss audiometry includes quantitative testing for a hearing deficit. An audiometer is used to measure and record thresholds of hearing by air conduction and bone conduction tests. The test results determine if hearing loss is conductive, sensorineural, or a combination of both. An elevated air-conduction threshold with a normal bone-conduction threshold indicates a conductive hearing loss. An equally elevated threshold for both air and bone conduction indicates a sensorineural

hearing loss. An elevated threshold of air conduction that is greater than an elevated threshold of bone conduction indicates a composite of both types of hearing loss. A conductive hearing loss is caused by an abnormality in the external auditory canal or middle ear, and a sensorineural hearing loss by an abnormality in the inner ear or of the VIII (auditory) nerve. Sensorineural hearing loss can be further differentiated clinically by sensory (cochlear) or neural (VIII nerve) lesions. Additional information for comparing and differentiating between conductive and sensorineural hearing loss can be obtained from hearing loss tuning fork tests.

INDICATIONS:

- Determine the need for a type of hearing aid and evaluate its effectiveness
- Determine the type and extent of hearing loss and if further radiologic, audiologic, or vestibular procedures are needed to identify the cause
- Evaluate communication disabilities and plan for rehabilitation interventions
- Evaluate degree and extent of preoperative and postoperative hearing loss following stapedectomy in patients with otosclerosis
- Screen for hearing loss in infants and children and determine the need for a referral to an audiologist

RESULT:

ASHA Category	Pure Tone Averages
Normal Range or No Impairment	0–20 dB*
Mild Loss	20–40 dB
Moderate Loss	40–60 dB
Severe Loss	60–80 dB
Profound Loss	Greater than 80 dB

*dB = decibel

Normal findings in:

- Normal pure tone average of 0 to 20 dB for infants, children, or adults.

Abnormal findings in:

- Causes of conductive hearing loss
 - Obstruction of external ear canal
 - Otitis externa
 - Otitis media
 - Otosclerosis
- Causes of sensorineural hearing loss
 - Congenital damage or malformations of the inner ear
 - Ototoxic drugs
 - Serious infections
 - Trauma to the inner ear
 - Tumor
 - Vascular disorders
- Obstructions of the ear canal by cerumen or other material or object will affect decibel (dB) perception.
- Noisy environment or extraneous movements can affect results.
- Tinnitus or other sensations can cause abnormal responses.
- Improper earphone fit or audiometer calibration can affect results.
- Failure to follow pretesting preparations before the procedure may cause the procedure to be canceled or repeated.

CRITICAL VALUES: N/A

INTERFERING FACTORS:**Factors that may impair the results of the examination:**

- Inability of the patient to cooperate or remain still during the procedure because of age, language barriers, significant pain, or mental status may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient/caregiver that the procedure detects hearing loss.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.

- ▶ Obtain a history of the patient's known or suspected hearing loss, including type and cause; ear conditions with treatment regimens; ear surgery; and other tests and procedures to assess and diagnose auditory deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that no discomfort will be experienced during the test. Inform the patient that an audiologist or health care provider (HCP) specializing in this procedure performs the test in a quiet, soundproof room, and that the test can take up 20 min to evaluate both ears. Explain that each ear will be tested separately by using earphones and/or a device placed behind the ear to deliver sounds of varying intensities. Address concerns about claustrophobia, as appropriate. Explain and demonstrate to the patient how to communicate with the audiologist and how to exit from the room.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ Ensure that the external auditory canal is clear of impacted cerumen.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still during the procedure because movement produces unreliable results.

- ▶ Perform otoscopy examination to ensure that the external ear canal is free from any obstruction (see monograph titled "Otoscopy").
- ▶ Test for closure of the canal from the pressure of the earphones by compressing the tragus. Tendency for the canal to close (often the case in children and elderly patients) can be corrected by the careful insertion of a small stiff plastic tube into the anterior canal.
- ▶ Place the patient in a sitting position in comfortable proximity to the audiometer in a soundproof room. The ear not being tested is masked to prevent crossover of test tones and the earphones are positioned on the head and over the ear canals. Infants and children may be tested using earphones that are inserted into the ear, unless contraindicated. An oscillating probe may be placed over the mastoid process behind the ear or on the forehead if bone conduction testing is to be performed as part of the hearing assessment.
- ▶ Start the test by providing a trial tone of 15–20 dB above the expected threshold to the ear for 1 to 2 sec to familiarize the patient with the sounds. Instruct the patient to press the button each time a tone is heard, no matter how loudly or faintly it is perceived. If no response is indicated, the level is increased until a response is obtained and then raised in 10-dB increments or until the audiometer's limit is reached for the test frequency. The test results are plotted on a graph called an audiogram using symbols that indicate the ear tested and responses using earphones (air conduction) or oscillator (bone conduction).

Air Conduction:

- ▶ Air conduction is tested first by starting at 1000 Hz and gradually decreasing the intensity 10 dB at a time until the patient no longer presses the button, indicating that the tone is no longer heard. The intensity is then increased 5 dB at a

time until the tone is heard again. This is repeated until the same response is achieved at a 50% response rate at the same hertz (Hz) level. The threshold is derived from the lowest decibel level at which the patient correctly identifies three out of six responses to a tone at that hertz level. The test is continued for each ear, testing the better ear first, with tones delivered at 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz, and then again at 1000 Hz, 500 Hz, and 250 Hz to determine a second threshold. Results are recorded on a graph called an audiogram. Averaging the air conduction thresholds at the 500-Hz, 1000-Hz, and 2000-Hz levels reveals the degree of hearing loss and is called the pure tone average (PTA).

Bone Conduction:

- ◆ Bone conduction testing is performed in a similar manner to air conduction testing. The raised and lowered tones are delivered as in air conduction using 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz to determine the thresholds. An analysis of thresholds for air and bone conduction tones is done to determine the type of hearing loss (conductive, sensorineural, or mixed).
- ◆ In children between 6 mo and 2 yr of age, minimal response levels can be determined by behavioral responses to test tone. In the child 2 yr and older, play audiometry that requires the child to perform a task or raise a hand in response to a specific tone is performed. In children 12 yr and older, the child is asked to follow directions in identifying objects; response to speech of specific intensities can be used to evaluate hearing loss that is affected by speech frequencies.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual activity, as directed by the HCP.
- ◆ Recognize anxiety related to test results, and be supportive of impaired activity related to hearing loss or perceived loss of independence. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Speech-Language-Hearing Association (www.asha.org) or for assistive technology at ABLEDATA (sponsored by the National Institute on Disability and Rehabilitation Research www.abledata.com).
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. As appropriate, instruct the patient in the use, cleaning, and storing of a hearing aid. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include evoked brain potential studies for hearing loss, otoscopy, spondee speech reception threshold, and tuning fork tests (Webber, Rinne).
- ◆ Refer to the table of tests associated with the Auditory System at the back of the book.

Barium Enema

SYNONYM/ACRONYM: Air-contrast barium enema, double-contrast barium enema, lower GI series, BE.

AREA OF APPLICATION: Colon.

CONTRAST: Barium sulfate, air, iodine mixture.

DESCRIPTION: This radiological examination of the colon, distal small bowel, and occasionally the appendix follows instillation of barium using a rectal tube inserted into the rectum or an existing ostomy. The patient must retain the barium while a series of radiographs are obtained. Visualization can be improved by using air or barium as the contrast medium (double-contrast study). A combination of x-ray and fluoroscopy techniques is used to complete the study. This test is especially useful in the evaluation of patients experiencing lower abdominal pain, changes in bowel habits, or the passage of stools containing blood or mucus, and for visualizing polyps, diverticula, and tumors. A barium enema may be therapeutic; it may reduce an obstruction caused by intussusception, or telescoping of the intestine. Barium enema should be performed before an upper gastrointestinal (GI) study or barium swallow.

INDICATIONS:

- Determine the cause of rectal bleeding, blood, pus, or mucus in feces
- Evaluate suspected inflammatory process, congenital anomaly, motility disorder, or structural change
- Evaluate unexplained weight loss, anemia, or a change in bowel pattern
- Identify and locate benign or malignant polyps or tumors

RESULT:

Normal findings in:

- Normal size, filling, shape, position, and motility of the colon
- Normal filling of the appendix and terminal ileum


Abnormal findings in:

- Appendicitis
- Colorectal cancer
- Congenital anomalies
- Crohn's disease
- Diverticular disease
- Fistulas
- Gastroenteritis
- Granulomatous colitis
- Hirschsprung's disease
- Intussusception
- Perforation of the colon
- Polyps
- Sarcoma
- Sigmoid torsion
- Sigmoid volvulus
- Stenosis
- Tumors
- Ulcerative colitis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shell fish or iodinated dye, when iodinated contrast medium is used. The contrast medium, when used, may cause life-threatening allergic reaction. Patients with a known hypersensitivity to contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are pregnant or suspected of being pregnant,

unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.

- Patients with intestinal obstruction, acute ulcerative colitis, acute diverticulitis, megacolon, or suspected rupture of the colon.

Factors that may impair clear imaging:

- Gas or feces in the GI tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects within the examination field (e.g., jewelry, body rings)
- Improper adjustment of the radiographic equipment to accommodate obese or thin patients
- Incorrect patient positioning, which may produce poor visualization of the area to be examined
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Spasm of the colon, which can mimic the radiographic signs of cancer (*Note:* the use of intravenous glucagon minimizes spasm)
- Inability of the patient to tolerate introduction of, or retention of barium, air, or both in the bowel

Other considerations:

- Complications of the procedure may include hemorrhage and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent

x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the area during the examination should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses the colon.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ♦ Obtain a history of the patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Verify that this procedure is performed before an upper GI study or barium swallow.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ♦ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is performed in a radiology department, by a HCP specializing in this procedure, with support staff, and takes approximately 30 min.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ Patients with a colostomy will be ordered special preparations and colostomy irrigation.

- ◆ Inform the patient that a laxative and cleansing enema may be needed the day before the procedure, with cleansing enemas on the morning of the procedure, depending on the institution's policy.
- ◆ Instruct the patient to remove all metallic objects from the area of the procedure.
- ◆ Instruct the patient to eat a low-residue diet for several days before the procedure and to consume only clear liquids the evening before the test. The patient should fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.

INTRATEST:

- ◆ Ensure the patient has complied with dietary, fluid, and medication restrictions and pretesting preparations.
- ◆ Ensure the patient has removed all external metallic objects from the area to be examined.
- ◆ Assess for completion of bowel preparation according to the institution's procedure.
- ◆ Have emergency equipment readily available.
- ◆ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ◆ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.
- ◆ Place the patient in the supine position on an exam table and take an initial image.
- ◆ Instruct the patient to lie on their left side (Sims' position). A rectal tube is inserted into the anus and an attached balloon is inflated after it is situated against the anal sphincter.
- ◆ Barium is instilled into the colon by gravity, and its movement through the colon is observed by fluoroscopy.
- ◆ For patients with a colostomy, an indwelling urinary catheter is inserted into the stoma and barium is administered.
- ◆ Images are taken with the patient in different positions to aid in the diagnosis.
- ◆ If a double-contrast barium enema has been ordered, air is then instilled in the intestine and additional images are taken.

- ◆ The patient is helped to the bathroom to expel the barium, or placed on a bedpan if unable to ambulate.
- ◆ After expulsion of the barium, a post-evacuation image is taken of the colon.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual diet, medications, or activity, as directed by the HCP.
- ◆ Instruct the patient to take a mild laxative and increase fluid intake (four 8-oz glasses) to aid in elimination of barium, unless contraindicated.
- ◆ Carefully monitor the patient for fatigue and fluid and electrolyte imbalance.
- ◆ Instruct the patient that stools will be white or light in color for 2 to 3 days. If the patient is unable to eliminate the barium, or if stools do not return to normal color, the patient should notify the HCP.
- ◆ Advise patients with a colostomy that tap water colostomy irrigation may aid in barium removal.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include cancer antigens, colonoscopy, colposcopy, CT abdomen, fecal analysis, MRI abdomen, PET pelvis, and proctosigmoidoscopy.
- ◆ Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Barium Swallow

B

SYNONYM/ACRONYM: Esophagram, video swallow, esophagus x-ray, swallowing function, esophography.

AREA OF APPLICATION: Esophagus.

CONTRAST: Barium sulfate, water-soluble iodinated contrast.

DESCRIPTION: This radiological examination of the esophagus evaluates motion and anatomic structures of the esophageal lumen by recording images of the lumen while the patient swallows a barium solution of milkshake consistency and chalky taste. The procedure uses fluoroscopic and cineradiographic techniques. The barium swallow is often performed as part of an upper gastrointestinal (GI) series or cardiac series and is indicated for patients with a history of dysphagia and gastric reflux. The study may identify reflux of the barium from the stomach back into the esophagus. Muscular abnormalities such as achalasia, as well as diffuse esophageal spasm, can be easily detected with this procedure.

INDICATIONS:

- Confirm the integrity of esophageal anastomoses in the postoperative patient
- Detect esophageal reflux, tracheo-esophageal fistulas, and varices
- Determine the cause of dysphagia or heartburn
- Determine the type and location of foreign bodies within the pharynx and esophagus

- Evaluate suspected esophageal motility disorders
- Evaluate suspected polyps, strictures, Zenker's diverticula, tumor, or inflammation

RESULT:

Normal findings in:

- Normal peristalsis through the esophagus into the stomach with normal size, filling, patency, and shape of the esophagus

Abnormal findings in:

- Achalasia
- Acute or chronic esophagitis
- Benign or malignant tumors
- Chalasia
- Diverticula
- Esophageal ulcers
- Esophageal varices
- Hiatal hernia
- Perforation of the esophagus
- Strictures or polyps

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Patients with intestinal obstruction or suspected esophageal rupture,

unless water-soluble iodinated contrast medium is used

- Patients with suspected tracheo-esophageal fistula, unless barium is used

Factors that may impair clear imaging:

- Metallic objects within the examination field
- Improper adjustment of the radiographic equipment to accommodate obese or thin patients, which can cause overexposure or underexposure
- Incorrect patient positioning, which may produce poor visualization of the area to be examined
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- A potential complication of a barium swallow is barium-induced fecal impaction.
- Ensure that the procedure is done after cholangiography and barium enema.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the esophagus.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that this procedure is performed before an upper GI study or video swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort. Review the procedure with the patient and explain the need to swallow a barium contrast medium. Inform the patient that the procedure is performed in a radiology department by a HCP and takes approximately 15 to 30 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove all external metallic objects from the area to be examined.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure the patient has complied with dietary and fluid restrictions for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.

- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate and follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Instruct the patient to stand in front of the x-ray fluoroscopy screen. Place the patient supine on the radiographic table if he or she is unable to stand.
- ▶ An initial image is taken, and the patient is asked to swallow a barium solution with or without a straw.
- ▶ Multiple images at different angles may be taken.
- ▶ The patient may be asked to drink additional barium to complete the study. Swallowing the additional barium evaluates the passage of barium from the esophagus into the stomach.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
- ▶ Carefully monitor the patient for fatigue and fluid and electrolyte imbalance.
- ▶ Instruct the patient to take a mild laxative and increase fluid intake (four 8-oz

glasses) to aid in elimination of barium, unless contraindicated.

- ▶ Instruct the patient that stools will be white or light in color for 2 to 3 days. If the patient is unable to eliminate the barium, or if stools do not return to normal color, the patient should notify the requesting HCP.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include capsule endoscopy, chest x-ray, CT thoracic, endoscopy, esophageal manometry, gastroesophageal reflux scan, MRI chest, and thyroid scan.
- ▶ Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Bilirubin and Bilirubin Fractions

SYNONYM/ACRONYM: Conjugated/direct bilirubin, unconjugated/indirect bilirubin, delta bilirubin, TBil.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube or in a heparinized microtainer is also acceptable. Protect sample from direct light.

REFERENCE VALUE: (Method: Spectrophotometry) Total bilirubin levels in infants should decrease to adult levels by day 10 as the development of the hepatic

circulatory system matures. Values in breastfed infants may take longer to reach normal adult levels. Values in premature infants may initially be higher than in full-term infants and also take longer to decrease to normal levels.

Bilirubin	Conventional Units	SI Units (Conventional Units × 17.1)
Total bilirubin		
<i>Newborn–1 d</i>	1.4–8.7 mg/dL	24–149 micromol/L
<i>1–2 d</i>	3.4–11.5 mg/dL	58–97 micromol/L
<i>3–5 d</i>	1.5–12.0 mg/dL	26–205 micromol/L
<i>1 mo–adult</i>	0.3–1.2 mg/dL	5–21 micromol/L
Unconjugated bilirubin	Less than 1.1 mg/dL	Less than 19 micromol/L
Conjugated bilirubin	Less than 0.3 mg/dL	Less than 5 micromol/L
Delta bilirubin	Less than 0.2 mg/dL	Less than 3 micromol/L

DESCRIPTION: Bilirubin is a by-product of heme catabolism from aged red blood cells. Bilirubin is primarily produced in the liver, spleen, and bone marrow. Total bilirubin is the sum of unconjugated bilirubin, monoglucuronide and diglucuronide, conjugated bilirubin, and albumin-bound delta bilirubin. Unconjugated bilirubin is carried to the liver by albumin, where it becomes conjugated. In the small intestine, conjugated bilirubin converts to urobilinogen and then to urobilin. Urobilin is then excreted in the feces. Increases in bilirubin levels can result from prehepatic, hepatic, and/or posthepatic conditions, making fractionation useful in determining the cause of the increase in total bilirubin levels. Delta bilirubin has a longer half-life than the other bilirubin fractions and therefore remains elevated during convalescence after the other fractions have decreased to normal levels. When bilirubin concentration increases, the yellowish pigment deposits in skin and sclera. This increase in yellow pigmentation is termed *jaundice* or *icterus*. Bilirubin levels can also be checked using noninvasive

methods. Defects in bilirubin excretion can be identified in a routine urinalysis. Hyperbilirubinemia in neonates can be reliably evaluated using transcutaneous measurement devices.

INDICATIONS:

- Assist in the differential diagnosis of obstructive jaundice
- Assist in the evaluation of liver and biliary disease
- Monitor the effects of drug reactions on liver function
- Monitor the effects of phototherapy on jaundiced newborns
- Monitor jaundice in newborn patients

RESULT:


Increased in:

- Prehepatic (hemolytic) jaundice (***excessive amounts of heme released from RBC destruction are catabolyzed to bilirubin in concentrations that exceed the liver's conjugation capacity and indirect bilirubin accumulates***)
Erythroblastosis fetalis
Hematoma

- Hemolytic anemias
- Pernicious anemia
- Physiologic jaundice of the newborn
- The post–blood transfusion period, when a number of units are rapidly infused or in the case of a delayed transfusion reaction
- Red blood cell enzyme abnormalities (i.e., glucose-6-phosphate dehydrogenase, pyruvate kinase, spherocytosis)
- Hepatic jaundice—**bilirubin conjugation failure**
 - Crigler-Najjar syndrome
 - Hepatic jaundice—**disturbance in bilirubin transport**
 - Dubin-Johnson syndrome (**preconjugation transport failure**)
 - Gilbert's syndrome (**postconjugation transport failure**)
 - Hepatic jaundice—**liver damage or necrosis interferes with excretion into bile ducts either by physical obstruction or drug inhibition and bilirubin accumulates**
 - Alcoholism
 - Cholangitis
 - Cholecystitis
 - Cholestatic drug reactions
 - Cirrhosis
 - Hepatitis
 - Hepatocellular damage
 - Infectious mononucleosis
- Posthepatic jaundice
 - Advanced tumors of the liver
 - Biliary obstruction
- Other conditions
 - Anorexia or starvation
 - Premature or breastfed infants
 - Hypothyroidism

Decreased in: N/A

CRITICAL VALUES:

 Greater than 15 mg/dL
Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms.

Sustained hyperbilirubinemia can result in brain damage. *Kernicterus* refers to the deposition of bilirubin in

the basal ganglia and brainstem nuclei. There is no exact level of bilirubin that puts infants at risk for developing kernicterus. Symptoms of kernicterus in infants include lethargy, poor feeding, upward deviation of the eyes, and seizures. Intervention for infants may include early frequent feedings to stimulate gastrointestinal motility, phototherapy, and exchange transfusion.

INTERFERING FACTORS:

- Drugs that may increase bilirubin levels by causing cholestasis include amitriptyline, anabolic steroids, androgens, benzodiazepines, chlorothiazide, chlorpropamide, dapsone, erythromycin, estrogens, ethionamide, gold salts, mipramine, mercaptopurine, nitrofurans, oral contraceptives, penicillins, phenothiazines, progesterone, propoxyphene, sulfonamides, tamoxifen, and tolbutamide.
- Drugs that may increase bilirubin levels by causing hepatocellular damage include acetaminophen (toxic), acetylsalicylic acid, allopurinol, amiodarone, anabolic steroids, anticonvulsants, asparaginase, azithromycin, bromocriptine, captopril, cephalosporins, chloramphenicol, clindamycin, clofibrate, danazol, enflurane, ethambutol, ethionamide, fenofibrate, fluconazole, fluoroquinolones, foscarnet, gentamicin, indomethacin, interferon, interleukin-2, levamisole, levodopa, lincomycin, low-molecular-weight heparin, methyl dopa, monoamine oxidase inhibitors, naproxen, nifedipine, nitrofurans, oral contraceptives, probenecid, procainamide, quinine, ranitidine, retinol, ritodrine, sulfonylureas, tetracyclines, tobramycin, and verapamil.
- Drugs that may increase bilirubin levels by causing hemolysis include amphotericin B,

carbamazepine, carbutamide, cephaloridine, cephalothin, chlorpromazine, chlorpropamide, dinitrophenol, ibuprofen, insulin, isoniazid, levodopa, mefenamic acid, melphalan, methotrexate, methylodopa, penicillins, phenacetin, procainamide, quinidine, quinine, rifampin, stibophen, sulfonamides, and tolbutamide.

- Bilirubin is light sensitive. Therefore, the collection container should be suitably covered to protect the specimen from light between the time of collection and analysis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess liver function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medication, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological

support before, during, and after the procedure.

- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Protect the specimen from light and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ *Nutritional considerations:* Increased bilirubin levels may be associated with liver disease. Dietary recommendations may be indicated depending on the condition and severity of the condition. Currently, for example, there are no specific medications that can be given to cure hepatitis, but elimination of alcohol consumption and a diet optimized for convalescence are commonly included in the treatment plan. A high-calorie, high-protein, moderate-fat diet with a high fluid intake is often recommended for the patient with hepatitis. Treatment of cirrhosis is different because a low-protein diet may be in order if the patient's liver has lost the ability to process the end products of protein

metabolism. A diet of soft foods may also be required if esophageal varices have developed. Ammonia levels may be used to determine whether protein should be added to or reduced from the diet. Patients should be encouraged to eat simple carbohydrates and emulsified fats (as in homogenized milk or eggs), as opposed to complex carbohydrates (e.g., starch, fiber, and glycogen [animal carbohydrates]) and complex fats, which require additional bile to emulsify them so that they can be used. The cirrhotic patient should be carefully observed for the development of ascites, in which case fluid and electrolyte balance requires strict attention. The alcoholic patient should be encouraged to avoid alcohol and also to seek appropriate counseling for substance abuse.

- ▶ Intervention for hyperbilirubinemia in the neonatal patient may include early frequent feedings (to stimulate gastrointestinal motility), phototherapy, and exchange transfusion.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.

Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, albumin, ALP, ammonia, amylase, AMA/ASMA, α_1 -antitrypsin/phenotyping, AST, biopsy liver, cholesterol, coagulation factor assays, complete blood count, cholangiography percutaneous transhepatic, cholangiography post-op, CT biliary tract and liver, copper, ERCP, GGT, hepatobiliary scan, hepatitis serologies, infectious mononucleosis screen, lipase, liver and spleen scan, protein total and fractions, PT/INR, US liver, and UA.
- ▶ See the Hepatobiliary System table at the end of the book for related tests by body system.

Biopsy, Bladder

SYNONYM/ACRONYM: N/A.

SPECIMEN: Bladder tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue) No abnormal tissue or cells.

DESCRIPTION: Biopsy is the excision of a sample of tissue that can be analyzed microscopically to determine cell morphology and the presence of tissue

abnormalities. This test is used to assist in confirming the diagnosis of cancer when clinical symptoms or other diagnostic findings are suspicious.

A urologist performs a biopsy of the bladder during cystoscopic examination. The procedure is usually carried out under general anesthesia. After the bladder is filled with saline for irrigation, the bladder and urethra are examined by direct and lighted visualization using a cystoscope. A sample of suspicious bladder tissue is then excised and examined macroscopically and microscopically to determine the presence of cell morphology and tissue abnormalities.

INDICATIONS:

- Assist in confirmation of malignant lesions of the bladder or ureter, especially if tumor is seen by radiological examination
- Assist in the evaluation of cases in which symptoms such as hematuria persist after previous treatment (e.g., removal of polyps or kidney stones)
- Monitor existing recurrent benign lesions for malignant changes


RESULT:

- **Positive findings in neoplasm of the bladder or ureter.**

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

- This test is contraindicated in patients with an acute infection of the bladder, urethra, or prostate.
-  This procedure is contraindicated in patients with bleeding disorders.

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to establish a diagnosis of bladder disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's genitourinary and immune systems, any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Inform the patient that back pain and burning or pressure in the genital area may be experienced after the procedure. Prophylactic antibiotics may be administered before the

procedure in certain cases. Address concerns about pain and explain that a general anesthesia will be administered prior to the biopsy. Explain that no pain will be experienced during the biopsy. Inform the patient that the biopsy is performed under sterile conditions by a HCP specializing in this procedure. The procedure usually takes about 30 to 45 min to complete.

- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ Explain that an IV line will be inserted to allow infusion of IV fluids, antibiotics, anesthetics, and analgesics.
- ◆ Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic, or that only clear liquids may be taken for 8 hr prior to the procedure if local anesthesia is to be used. Protocols may vary from facility to facility.
- ◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ◆ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 6 to 8 hr prior to the procedure.
- ◆ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ◆ Have emergency equipment readily available.
- ◆ Have the patient void before the procedure.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the

corresponding patient demographics, date and time of collection, and site location.

- ◆ Assist the patient to a comfortable position, and direct the patient to breathe normally during the beginning of the general anesthetic.
- ◆ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.

Cystoscopy:

- ◆ After administration of general anesthesia, place the patient in a lithotomy position on the examination table (with the feet up in stirrups). Drape the patient's legs. Clean the external genitalia with a suitable antiseptic solution and drape the area with sterile towels.
- ◆ Once the cystoscope is inserted, the bladder is irrigated with saline. A tissue sample is removed using a cytology brush or biopsy forceps. Catheters may be used to obtain samples from the ureter.

Open Biopsy:

- ◆ After administration of general anesthesia and surgical prep are completed, an incision is made, suspicious areas are located, and tissue samples are collected.

General:

- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ◆ Place tissue samples in properly labeled specimen container containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- ◆ Monitor vital signs and neurologic status every 15 min for 1 hr, then

every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.

- ▶ Monitor fluid intake and output for 24 hr. Instruct the patient on intake and output recording and provide appropriate measuring containers.
- ▶ Encourage fluid intake of 3000 mL in 24 hr, unless contraindicated.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report pain, chills, or fever. Assess for infection, hemorrhage, or perforation of the bladder.
- ▶ Inform the patient that blood may be seen in the urine after the first or second postprocedural voiding.
- ▶ Instruct the patient to report any further changes in urinary pattern, volume, or appearance.

Open Biopsy:

- ▶ Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to keep the site clean and change the dressing as needed.

General:

- ▶ Assess for nausea, pain, and bladder spasms. Administer antiemetic, analgesic, and antispasmodic medications as needed and as directed by the HCP.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of

antibiotic therapy, even if signs and symptoms disappear before completion of therapy.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include calculus kidney stone panel, cystometry, cystoscopy, cystourethrography voiding, IVP, KUB studies, MRI bladder, US bladder, UA, and urine bladder cancer markers.
- ▶ Refer to the Genitourinary and Immune System tables at the back of the book for related tests by body system.

Biopsy, Bone

B

SYNONYM/ACRONYM: N/A.

SPECIMEN: Bone tissue.

REFERENCE VALUE: (Method: Microscopic study of bone samples) No abnormal tissue or cells.

DESCRIPTION: Biopsy is the excision of a sample of tissue that can be analyzed microscopically to determine cell morphology and the presence of tissue abnormalities. This test is used to assist in confirming the diagnosis of cancer when clinical symptoms or x-rays are suspicious. After surgical incision to reveal the affected area, bone biopsy is obtained. An alternative collection method is needle biopsy, in which a plug of bone is removed using a special serrated needle.

INDICATIONS:

- Differentiation of a benign from a malignant bone lesion
- Radiographic evidence of a bone lesion

RESULT:


Abnormal findings in:

- Ewing's sarcoma
- Multiple myeloma
- Osteoma
- Osteosarcoma

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  This procedure is contraindicated in patients with bleeding disorders.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to establish a diagnosis of bone disease.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ♦ Obtain a history of the patient's immune and musculoskeletal systems, especially any bleeding disorders and other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and

nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.

- Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; general anesthesia will be administered prior to the open biopsy. Explain to the patient that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a HCP specializing in this procedure. The surgical procedure usually takes about 30 min to complete, and sutures may be necessary to close the site. A needle biopsy usually takes about 20 min to complete.

- Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- Explain that an IV line will be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.

Open Biopsy:

- Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.

Needle Biopsy:

- Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.

General:

- Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- Ensure that the patient has complied with dietary restrictions; assure that

food has been restricted for at least 4 to 8 hr depending on the anesthetic chosen for the procedure.

- Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- Have emergency equipment readily available.
- Have the patient void before the procedure.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- Assist the patient to the desired position depending on the test site to be used, and direct the patient to breathe normally during the beginning of the general anesthetic. Instruct the patient to cooperate fully and to follow directions. For the patient undergoing local anesthesia, direct him or her to breathe normally and to avoid unnecessary movement during the procedure.
- Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Open Biopsy:

- After administration of general anesthesia and surgical prep are completed, an incision is made, suspicious area(s) are located, and tissue samples are collected.

Needle Biopsy:

- Instruct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes. A small incision is made and the biopsy needle is inserted to remove the specimen. Pressure is applied to the site for 3 to 5 min, then a sterile pressure dressing is applied.

General:

- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ◆ Place tissue samples in properly labeled specimen container containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- ◆ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ◆ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- ◆ Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed.
- ◆ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ◆ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if

signs and symptoms disappear before completion of therapy.

- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for removal of sutures, if indicated. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ALP, biopsy bone marrow, bone scan, calcium, complete blood count, cortisol, immunofixation electrophoresis, immunoglobulins A, G, and M, β_2 -microglobulin, MRI musculoskeletal, PTH, phosphorus, total protein and fractions, UA, and vitamin D.
- ◆ See the Immune and Musculoskeletal System tables at the end of the book for related tests by body system.

Biopsy, Bone Marrow

SYNONYM/ACRONYM: N/A.

SPECIMEN: Bone marrow aspirate, bone core biopsy, marrow and peripheral smears.

REFERENCE VALUE: (Method: Microscopic study of bone and bone marrow samples, flow cytometry) Reference ranges are subject to many variables, and therefore the laboratory should be consulted for their specific interpretation. Some generalities may be commented on regarding findings as follows:

- Ratio of marrow fat to cellular elements is related to age, with the amount of fat increasing with increasing age.
- Normal cellularity, cellular distribution, presence of megakaryocytes, and absence of fibrosis or tumor cells.
- The myeloid-to-erythrocyte ratio (M:E) is 2:1 to 4:1 in adults. It may be slightly higher in children.

Differential Parameter	Conventional Units
Erythrocyte precursors	18–32%
Myeloblasts	0–2%
Promyelocytes	2–6%
Myelocytes	9–17%
Metamyelocytes	7–25%
Bands	10–16%
Neutrophils	18–28%
Eosinophils and precursors	1–5%
Basophils and precursors	0–1%
Monocytes and precursors	1–5%
Lymphocytes	9–19%
Plasma cells	0–1%

DESCRIPTION: This test involves the removal of a small sample of bone marrow by aspiration, needle biopsy, or open surgical biopsy for a complete hematologic analysis. The marrow is a suspension of blood, fat, and developing blood cells, which is evaluated for morphology and examined for all stages of maturation; iron stores; and M:E. Sudan black B and periodic acid–Schiff (PAS) stains can be performed for microscopic

examination to differentiate the types of leukemia, although flow cytometry and cytogenetics have become more commonly used techniques for this purpose.

INDICATIONS:

- Determine marrow differential (proportion of the various types of cells present in the marrow) and M:E
- Evaluate abnormal results of complete blood count or white

blood cell count with differential showing increased numbers of leukocyte precursors

- Evaluate hepatomegaly or splenomegaly
- Identify bone marrow hyperplasia or hypoplasia
- Identify infectious organisms present in the bone marrow (histoplasmosis, mycobacteria, CMV, parvovirus inclusions)
- Monitor effects of exposure to bone marrow depressants
- Monitor bone marrow response to chemotherapy or radiation therapy

RESULT:

Increased Reticulocytes:

- Compensated red blood cell (RBC) loss
- Response to vitamin B₁₂ therapy

Decreased Reticulocytes:

- Aplastic crisis of sickle cell anemia or hereditary spherocytosis

Increased Leukocytes:

- *(General associations include compensation for infectious process, leukemias, or leukemoid drug reactions)*

Decreased Leukocytes:

- *(General associations include reduction in the marrow space as seen in metastatic neoplasm or myelofibrosis, lack of production of cells, lower production of cells as seen in the elderly, or following suppressive therapy such as chemo or radiation)*

Increased Neutrophils (Total):

- Acute myeloblastic leukemia
- Myeloid (chronic) leukemias

Decreased Neutrophils (Total):

- Aplastic anemia
- Leukemias (monocytic and lymphoblastic)

Increased Lymphocytes:

- Aplastic anemia
- Lymphatic leukemia
- Lymphomas
- Lymphosarcoma
- Mononucleosis
- Viral infections

Increased Plasma Cells:

- Cancer
- Cirrhosis of the liver
- Connective tissue disorders
- Hypersensitivity reactions
- Infections
- Macroglobulinemia
- Ulcerative colitis

Increased Megakaryocytes:

- Hemorrhage
- Increasing age
- Infections
- Megakaryocytic myelosis
- Myeloid leukemia
- Pneumonia
- Polycythemia vera
- Thrombocytopenia

Decreased Megakaryocytes:

- Agranulocytosis
- Cirrhosis of the liver
- Pernicious aplastic anemia
- Radiation therapy
- Thrombocytopenic purpura

Increased M:E:

- Bone marrow failure
- Infections
- Leukemoid reactions
- Myeloid leukemia

Decreased M:E:

- Anemias
- Hepatic disease
- Polycythemia vera
- Posthemorrhagic hematopoiesis

Increased Normoblasts:

- Anemias
- Chronic blood loss
- Polycythemia vera

Decreased Normoblasts:

- Aplastic anemia
- Folic acid or vitamin B₁₂ deficiency
- Hemolytic anemia


Increased Eosinophils:

- Bone marrow cancer
- Lymphadenoma
- Myeloid leukemia

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

- Recent blood transfusions, iron therapy, or administration of cytotoxic agents may alter test results.
-  This procedure is contraindicated in patients with known bleeding disorders.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to establish a diagnosis of bone marrow and immune system disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's hematopoietic and immune systems, especially any bleeding disorders and other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Note any recent procedures that can interfere with test results.

- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; a general anesthesia will be administered prior to the open biopsy. Explain to the patient that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a HCP specializing in this procedure. The surgical procedure usually takes about 30 min to complete, and sutures may be necessary to close the site. A needle biopsy usually takes about 20 min to complete.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives.
- ▶ Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 4 to 8 hr depending on the anesthetic chosen for the procedure.

- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Have the patient void before the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Assist the patient to the desired position depending on the test site to be used. In young children, the most frequently chosen site is the proximal tibia. Vertebral bodies T10 through L4 are preferred in older children. In adults, the sternum or iliac crests are the preferred sites. Place the patient in the prone, sitting, or side-lying position for the vertebral bodies; the side-lying position for iliac crest or tibial sites; or the supine position for the sternum. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Needle Aspiration:

- ▶ The HCP will anesthetize the site with procaine or lidocaine, and then insert a needle with stylet into the marrow. The stylet is removed, a syringe attached, and a 0.5-mL aliquot of marrow withdrawn. The needle is removed, and pressure is applied to the site. The aspirate is applied to slides, and, when dry, a fixative is applied.

Needle Biopsy:

- ▶ Instruct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes.
- ▶ Local anesthetic is introduced deeply enough to include periosteum. A cutting biopsy needle is introduced through a small skin incision and bored into the marrow cavity. A core needle is introduced through the cutting needle, and a plug of marrow is removed. The needles are withdrawn, and the specimen is placed in a preservative solution. Pressure is applied to the site for 3 to 5 min, and then a pressure dressing is applied.

General:

- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ▶ Place tissue samples in properly labeled specimen container containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume preoperative diet, as directed by the HCP.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed.

- ▶ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for removal of sutures, if indicated. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy lymph node, complete blood count, LAP, immunofixation electrophoresis, mediastinoscopy, and vitamin B₁₂.
- ▶ Refer to the Hematopoietic and Immune System tables at the back of the book for related tests by body system.

Biopsy, Breast

SYNONYM/ACRONYM: N/A.

SPECIMEN: Breast tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue for biopsy; cytochemical or immunohistochemical for estrogen and progesterone receptors, Ki67, PCNA, P53; flow cytometry for DNA ploidy and S-phase fraction; immunohistochemical or FISH for Her-2/neu. Fluorescence in situ hybridization (FISH) is a cytogenetic technique that uses fluorescent labeled DNA probes to detect specific chromosome abnormalities.) Favorable findings:

- Biopsy: No abnormal cells or tissue
- DNA ploidy: Majority diploid cell population
- SPF: Low fraction of replicating cells in total cell population
- Her-2/neu, Ki67, PCNA, and P53: Negative to low percentage of stained cells
- Estrogen and Progesterone Receptors: High percentage of stained cells

DESCRIPTION: Breast cancer is the most common newly diagnosed cancer in American women. It is the second leading cause of cancer-related death. Biopsy is the excision of a sample of tissue that can be analyzed microscopically to determine cell morphology and the presence of tissue abnormalities. Fine needle and open biopsies of the breast have become more commonly ordered in recent years as increasing emphasis on early detection of breast cancer has become stronger. Breast biopsies are used to assist in the identification and prognosis of breast cancer. There are a number of tests that can be performed on breast tissue to assist in identification and management of breast cancer.

Estrogen and progesterone receptor assays (ER and PR) are used to identify patients with a type of breast cancer that may be more responsive than other types of tumors to estrogen-deprivation (antiestrogen) therapy or removal of the ovaries. Patients with these types of tumors generally have a better prognosis. **DNA ploidy** testing by flow cytometry may also be performed on suspicious tissue. Cancer is the unchecked proliferation of tumor cells that contain abnormal amounts of DNA. The higher the grade of tumor cells, the more likely abnormal DNA will be detected. The **ploidy**, or number of chromosome sets in the nucleus, is an indication of the speed of cell replication and tumor growth. Cells synthesize DNA in the S phase of mitosis. **S-phase fraction (SPF)** is an indicator of the number of cells

undergoing replication. Normal tissue will have a higher percentage of resting diploid cells or cells containing two chromosomes. Aneuploid cells contain multiple chromosomes. Genes on the chromosomes are coded to produce specific proteins. **Ki67 and proliferating cell nuclear antigen (PCNA)** are examples of proteins that can be measured to indicate the degree of cell proliferation in biopsied tissue. Overexpression of a protein called **human epidermal growth factor receptor 2** (HER-2/neu oncoprotein) is helpful in establishing histologic evidence of metastatic breast cancer. Metastatic breast cancer patients with high levels of HER-2/neu oncoprotein have a poor prognosis. They have rapid tumor progression, increased rate of recurrence, poor response to standard therapies, and a lower survival rate. Herceptin (trastuzumab) is indicated for treatment of HER-2/neu overexpression. **P53** is a suppressor protein that normally prevents cells with abnormal DNA from multiplying. Mutations in the P53 gene cause the loss of P53 functionality; the checkpoint is lost and cancerous cells are allowed to proliferate.

INDICATIONS:

- Evidence of breast lesion by palpation, mammography, or ultrasound
- Identify patients with breast or other types of cancer that may respond to hormone or antihormone therapy

- Monitor responsiveness to hormone or antihormone therapy
- Observable breast changes such as “peau d’orange” skin, scaly skin of the areola, drainage from the nipple, or ulceration of the skin

RESULT:


Positive findings in:

- Carcinoma of the breast
- Hormonal therapy (ER and PR)
- Receptor-positive tumors (ER and PR)

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  This procedure is contraindicated in patients with bleeding disorders.
- Antiestrogen preparations (e.g., tamoxifen) ingested 2 mo before tissue sampling will affect test results (ER and PR).
- Pretesting preservation of the tissue is method and test dependent. The testing laboratory should be consulted for proper instructions prior to the biopsy procedure.
- Failure to transport specimen to the laboratory immediately can result in degradation of tissue. Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results.
- Massive tumor necrosis or tumors with low cellular composition falsely decrease results.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the tests are used to establish a diagnosis of breast disease; in the presence of breast or other types of cancer the tests are used to assist in the prognosis and management of response to therapy.
- ▶ Obtain a history of the patient’s complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient’s immune and reproductive systems, especially any bleeding disorders and other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Note any recent procedures that can interfere with test results. Ensure that the patient has not received antiestrogen therapy within 2 mo of the test.
- ▶ Obtain a list of the patient’s current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; a general anesthesia will be administered prior to the

open biopsy. Explain to the patient that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a health care provider (HCP) specializing in this procedure. The surgical procedure usually takes about 20 to 30 min to complete, and sutures may be necessary to close the site. A needle biopsy usually takes about 15 min to complete.

◆ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

◆ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.

Open Biopsy:

◆ Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.

Needle Biopsy:

◆ Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.

General:

◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

◆ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 4 to 8 hr depending on the anesthetic chosen for the procedure. Ensure that the patient has not received antiestrogen therapy within 2 mo of the test.

◆ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient

anticoagulant therapy has not been withheld.

◆ Have emergency equipment readily available.

◆ Have the patient void before the procedure.

◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location, especially left or right breast.

◆ Assist the patient to the desired position depending on the test site to be used, and direct the patient to breathe normally during the beginning of the general anesthetic. Instruct the patient to cooperate fully and to follow directions. For the patient undergoing local anesthesia, direct him or her to breathe normally and to avoid unnecessary movement during the procedure.

◆ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.

◆ After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Open Biopsy:

◆ After administration of general anesthesia and surgical prep are completed, an incision is made, suspicious area(s) are located, and tissue samples are collected.

Needle Biopsy:

◆ Direct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes. Instruct the patient to take a deep breathe, exhale forcefully, and hold the breathe while the biopsy needle is inserted and rotated to obtain a core of breast tissue. Once the needle is removed, the patient may breathe. Pressure is applied to the site for 3 to 5 min, then a sterile pressure dressing is applied.

General:

◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).

- Place tissue samples in formalin solution. Label the specimen, indicating site location, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed.
- Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Recognize anxiety related to test results. Discuss the implications of

abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Cancer Society (<http://www.cancer.org>).

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for removal of sutures, if indicated. Instruct and educate the patient how to perform monthly breast self-examination and emphasize, as appropriate, the importance of having a mammogram performed annually. Answer any questions or address any concerns voiced by the patient or family.
- Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage the patient to review corresponding literature provided by a pharmacist.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include cancer antigens, mammogram, MRI breast, stereotactic biopsy breast, and US breast.
- Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Biopsy, Cervical

B **SYNONYM/ACRONYM:** Cone Biopsy, LEEP.

SPECIMEN: Cervical tissue.

REFERENCE VALUE: (Method: Microscopic examination of tissue cells) No abnormal cells or tissue.

DESCRIPTION: Biopsy is the excision of a sample of tissue that can be analyzed microscopically to determine cell morphology and the presence of tissue abnormalities. The cervical biopsy is used to assist in confirmation of cancer when screening tests are positive. Cervical biopsy is obtained using an instrument that punches into the tissue and retrieves a tissue sample. Schiller's test entails applying an iodine solution to the cervix. Normal cells pick up the iodine and stain brown. Abnormal cells do not pick up any color. Punch biopsy results may indicate the need for a cone biopsy of the cervix. Cone biopsy is where a wedge shape of tissue is removed from the cervix by using a surgical knife, a carbon dioxide laser, or a loop electro-surgical excision procedure (LEEP). The LEEP procedure can be performed by placing the patient under a general anesthetic; by a regional anesthesia, such as a spinal or epidural; or by a cervical block, where a local anesthetic is injected into the cervix. The patient is given oral or IV pain medicine in conjunction with the local anesthetic when this method is used. Following

colposcopy or cervical biopsy, LEEP can be used to treat abnormal tissue identified on biopsy.

INDICATIONS:

- Follow-up to abnormal Papanicolaou (Pap) smear, Schiller's test, or colposcopy
- Suspected cervical malignancy

RESULT:


Positive findings in:

- Carcinoma in situ
- Cervical dysplasia
- Cervical polyps

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  The test is contraindicated in cases of acute pelvic inflammatory disease or bleeding disorders.
- This test should not be performed while the patient is menstruating.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to establish a diagnosis of cervical disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, or anesthetics.
- ▶ Obtain a history of the patient's immune and reproductive systems, especially any bleeding disorders and other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; general anesthesia will be administered prior to the open biopsy. Explain that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient the biopsy is performed under sterile conditions by a HCP specializing in this procedure. The surgical procedure usually takes about 20 to 30 min to complete, and sutures may be necessary to close the site.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.

LEEP as an Outpatient Procedure:

- ▶ Instruct the patient that nothing should be taken by mouth for at least 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.

LEEP in HCP's Office:

- ▶ Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.

General:

- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 4 to 8 hr depending on the anesthetic chosen for the procedure.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Have the patient void before the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Have the patient remove clothes below the waist. Assist the patient into a

lithotomy position on a gynecologic exam table (with feet in stirrups). Drape the patient's legs. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local or general anesthetic and the procedure.

Punch Biopsy:

- ▶ A small round punch is rotated into the skin to the desired depth. The cylinder of skin is pulled upward with forceps and separated at its base with a scalpel or scissors. If needed, sutures are applied. A sterile dressing is applied over the site.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

LEEP in the HCP's Office:

- ▶ A speculum is inserted into the vagina and is opened to gently spread apart the vagina for inspection of the cervix.
- ▶ The diseased tissue is removed along with a small amount of healthy tissue along the margins of the biopsy to ensure that no diseased tissue is left in the cervix after the procedure.

LEEP as an Outpatient Procedure:

- ▶ After administration of general anesthesia and surgical prep are completed, the procedure is carried out as noted above.

General:

- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ▶ Place tissue samples in properly labeled specimen container containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume preoperative diet, as directed by the HCP.

Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.

- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to expect a gray-green vaginal discharge for several days, some vaginal bleeding may occur for up to 1 wk but should not be heavier than a normal menses, and some pelvic pain may occur. Instruct the patient to avoid strenuous activity for 8 to 24 hr, to avoid douching or intercourse for 2 wk or as instructed, and to report excessive bleeding, chills, fever, or any other unusual findings to the HCP.
- ▶ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ Recognize anxiety related to test results and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the

patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage her to review corresponding literature provided by a pharmacist.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation

to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include chlamydia group antibodies, colposcopy, culture anal/genital, culture viral, Pap smear, and syphilis serology.
- See the Immune and Reproductive System tables at the back of the book for related tests by body system.

Biopsy, Chorionic Villus

SYNONYM/ACRONYM: N/A.

SPECIMEN: Chorionic villus tissue.

REFERENCE VALUE: (Method: Tissue culture) Normal karyotype.

DESCRIPTION: This test is used to detect fetal abnormalities caused by numerous genetic disorders. The advantage over amniocentesis is that it can be performed as early as the 8th wk of pregnancy, permitting earlier decisions regarding termination of pregnancy. However, unlike amniocentesis, this test will not detect neural tube defects.

INDICATIONS:

- Assist in the diagnosis of in utero metabolic disorders such as cystic fibrosis or other errors of lipid, carbohydrate, or amino acid metabolism
- Detect abnormalities in the fetus of women of advanced maternal age
- Determine fetal gender when the mother is a known carrier of a sex-linked abnormal gene that could be transmitted to male

offspring, such as hemophilia or Duchenne's muscular dystrophy

- Evaluate fetus in families with a history of genetic disorders, such as Down syndrome, Tay-Sachs disease, chromosome or enzyme anomalies, or inherited hemoglobinopathies

RESULT:

ABNORMAL KARYOTYPE: *Numerous genetic disorders. Generally, the laboratory provides detailed interpretive information regarding the specific chromosome abnormality detected.*

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

- ◆ The test is contraindicated in the patient with a history of or in the presence of incompetent cervix.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to establish a diagnosis of in utero genetic disorders.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ◆ Obtain a history of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Include any family history of genetic disorders such as cystic fibrosis, Duchenne's muscular dystrophy, hemophilia, sickle cell anemia, Tay-Sachs disease, thalassemia, and trisomy 21. Obtain maternal Rh type. If Rh-negative, check for prior sensitization.
- ◆ Record the date of the last menstrual period and determine that the pregnancy is in the first trimester between the 10th and 12th wk.
- ◆ Obtain a history of intravenous drug use, high-risk sexual activity, or occupational exposure.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Warn the patient that normal results do not guarantee a normal fetus. Assure the patient that precautions to avoid injury to the fetus will be taken by locating the fetus with ultrasound. Address concerns about pain related to the procedure. Explain that, during the transabdominal procedure, any discomfort with a needle biopsy will be minimized

with local anesthetics. Explain that, during the transvaginal procedure, some cramping may be experienced as the catheter is guided through the cervix. Encourage relaxation and controlled breathing during the procedure to aid in reducing any mild discomfort. Inform the patient that specimen collection is performed by a HCP specializing in this procedure and usually takes approximately 10 to 15 min to complete.

- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ◆ There are no food, fluid, or medication restrictions unless by medical direction.
- ◆ Instruct the patient to drink a glass of water about 30 min prior to testing so that the bladder is full. This elevates the uterus higher in the pelvis. The patient should not void before the procedure.

- ◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ◆ Ensure that the patient has a full bladder before the procedure.
- ◆ Have emergency equipment readily available.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ◆ Have the patient remove clothes below the waist. *Transabdominal:* Assist the patient into a supine position on the exam table with abdomen exposed. Drape the patient's legs, leaving abdomen exposed. *Transvaginal:* Assist the patient into a lithotomy position on a gynecologic examination table (with feet in stirrups). Drape the patient's legs. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ◆ Record maternal and fetal baseline vital signs, and continue to monitor throughout the procedure. Monitor for

uterine contractions. Monitor fetal vital signs using ultrasound. Protocols may vary from facility to facility.

- After the administration of local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Transabdominal Biopsy:

- Assess the position of the amniotic fluid, fetus, and placenta using ultrasound.
- A needle is inserted through the abdomen into the uterus, avoiding contact with the fetus. A syringe is connected to the needle and the specimen of chorionic villus cells is withdrawn from the uteroplacental area. Pressure is applied to the site for 3 to 5 min, then a sterile pressure dressing is applied.

Transvaginal Biopsy:

- Assess the position of the fetus and placenta using ultrasound.
- A speculum is inserted into the vagina and is opened to gently spread apart the vagina for inspection of the cervix. The cervix is cleansed with a swab of antiseptic solution.
- A catheter is inserted through the cervix into the uterus, avoiding contact with the fetus. A syringe is connected to the catheter and the specimen of chorionic villus cells is withdrawn from the uteroplacental area.

General:

- Monitor the patient for complications related to the procedure (e.g., premature labor, allergic reaction, anaphylaxis).
- Place tissue samples in formalin solution. Label the specimen, indicating site location, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- After the procedure, the patient is placed in the left side-lying position, and both maternal and fetal vital signs are monitored for at least 30 min. Protocols may vary from facility to facility.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.

- Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to keep the site clean and change the dressing as needed.
- Instruct the patient to expect mild cramping, leakage of small amount of amniotic fluid, and vaginal spotting for up to 2 days following the procedure. Instruct the patient to report moderate to severe abdominal pain or cramps, increased or prolonged leaking of amniotic fluid from vagina or abdominal needle site, vaginal bleeding that is heavier than spotting, and either chills or fever.
- Administer Rh₀(D) immune globulin (RhOGAM IM or Rhophylac IM or IV) to maternal Rh-negative patients to prevent maternal Rh sensitization should the fetus be Rh-positive.
- Administer mild analgesic and antibiotic therapy as ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Encourage family to seek counseling if concerned with pregnancy termination or to seek genetic counseling if chromosomal abnormality is determined. Decisions regarding elective abortion should take place in the presence of both parents. Provide a nonjudgmental, nonthreatening atmosphere for a discussion during which risks of delivering a developmentally challenged infant are discussed with options (termination of pregnancy or adoption). It is also important to discuss problems the mother and father may experience (guilt, depression, anger) if fetal abnormalities are detected.
- Reinforce information given by the patient's HCP regarding further testing,

treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may

be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amniotic fluid analysis, chromosome analysis, α_1 fetoprotein, HCG, hexosaminidase A and B, L/S ratio, and US obstetric.
- ▶ Refer to the Reproductive System table at the end of the book for related tests by body system.

Biopsy, Intestinal

SYNONYM/ACRONYM: N/A.

SPECIMEN: Intestinal tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue) No abnormal tissue or cells.

DESCRIPTION: Intestinal biopsy is the excision of a tissue sample from the small intestine for microscopic analysis to determine cell morphology and the presence of tissue abnormalities. This test assists in confirming the diagnosis of cancer or intestinal disorders. Biopsy specimen is usually obtained during endoscopic examination.

INDICATIONS:

- Assist in the diagnosis of various intestinal disorders, such as lactose and other enzyme deficiencies, celiac disease, and parasitic infections
- Confirm suspected intestinal malignancy

- Confirm suspicious findings during endoscopic visualization of the intestinal wall

RESULT:


Abnormal findings in:

- Cancer
- Celiac disease
- Lactose deficiency
- Parasitic infestation
- Tropical sprue

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

- Barium swallow within 48 hr of small intestine biopsy affects results.
-  This procedure is contraindicated in patients with bleeding disorders and aortic arch aneurysm.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to establish a diagnosis of intestinal disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's gastrointestinal and immune systems, any bleeding disorders, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Address concerns about pain and explain that a sedative may be administered to promote relaxation during the procedure. Inform the patient that the procedure is performed by a HCP specializing in this procedure and

usually takes about 60 min to complete.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, anesthetics, and analgesics.
- ▶ Explain that a clear liquid diet is to be consumed 1 day prior to the procedure. Then food and fluids are restricted for 6 to 8 hr before the test. Protocols may vary from facility to facility.
- ▶ Provide the patient with a gown, robe, and foot coverings and instruct him or her to void prior to the procedure.
- ▶ Instruct the patient to remove dentures, jewelry (including watches), hairpins, credit cards, and other metallic objects. Inform the HCP if the patient has any crowns or caps on the teeth.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 6 to 8 hr prior to the procedure if general anesthesia will be used.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Observe standard precautions and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Assist the patient into a semireclining position. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.

Esophagogastroduodenoscopy (EGD) Biopsy:

- A local anesthetic is sprayed into the throat. A protective tooth guard and a bite block may be placed in the mouth.
- The flexible endoscope is passed into and through the mouth, and the patient is asked to swallow. Once the endoscope passes into the esophagus, assist the patient into the left lateral position. A suction device is used to drain saliva.
- The esophagus, stomach, and duodenum are visually examined as the endoscope passes through each section. A biopsy specimen can be taken from any suspicious sites.
- Tissue samples are obtained by inserting a cytology brush or biopsy forceps through the endoscope.
- When the examination and tissue removal are complete, the endoscope and suction device are withdrawn and the tooth guard and bite block are removed.
- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- Place tissue samples in formalin solution. Label the specimen, indicating site location, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume usual diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- Instruct the patient to report any chest pain, upper abdominal pain, pain on

swallowing, difficulty breathing, or expectoration of blood. Report these to the HCP immediately.

- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- Administer mild analgesic and antibiotic therapy as ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include albumin, antibodies gliadin, calcium, cancer antigens, capsule endoscopy, colonoscopy, D-xylose tolerance, fecal analysis, fecal fat, folic acid, iron/TIBC, LTT, ova and parasite, potassium, PT/INR, sodium, vitamin B₁₂, and vitamin D.
- Refer to the Gastrointestinal and Immune System tables at the back of the book for related tests by body system.

Biopsy, Kidney

B

SYNONYM/ACRONYM: Renal biopsy.

SPECIMEN: Kidney tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue) No abnormal cells or tissue.

DESCRIPTION: Kidney or renal biopsy is the excision of a tissue sample from the kidney for microscopic analysis to determine cell morphology and the presence of tissue abnormalities. This test assists in confirming a diagnosis of cancer found on x-ray or ultrasound or to diagnose certain inflammatory or immunological conditions. Biopsy specimen is usually obtained either percutaneously or after surgical incision.

INDICATIONS:

- Assist in confirming suspected renal malignancy
- Assist in the diagnosis of the cause of renal disease
- Determine extent of involvement in systemic lupus erythematosus or other immunological disorders
- Monitor progression of nephrotic syndrome
- Monitor renal function after transplantation

RESULT:

Positive findings in:


- Acute and chronic poststreptococcal glomerulonephritis
- Amyloidosis infiltration
- Cancer
- Disseminated lupus erythematosus
- Goodpasture's syndrome

- Immunological rejection of transplanted kidney
- Nephrotic syndrome
- Pyelonephritis
- Renal venous thrombosis

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  This procedure is contraindicated in bleeding disorders, advanced renal disease, uncontrolled hypertension, or solitary kidney (except transplanted kidney).
- Obesity and severe spinal deformity can make percutaneous biopsy impossible.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to establish a diagnosis of kidney disease.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's genitourinary and immune system, especially any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; a general anesthesia will be administered prior to the open biopsy. Explain to the patient that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a HCP specializing in this procedure. The surgical procedure usually takes about 60 min to complete, and sutures may be necessary to close the site. A needle biopsy usually takes about 40 min to complete.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.

Open Biopsy:

- ▶ Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.

Needle Biopsy:

- ▶ Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.

General:

- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 4 to 8 hr depending on the anesthetic chosen for the procedure.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Have the patient void before the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location, especially left or right kidney.
- ▶ Assist the patient to the desired position depending on the test site to be used, and direct the patient to breathe normally during the beginning of the general anesthetic. Instruct the patient to cooperate fully and to follow directions. Direct the patient to avoid unnecessary movement.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ After the administration of general or local anesthesia, shave and

cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Open Biopsy:

- After administration of general anesthesia and surgical prep are completed, an incision is made, suspicious area(s) are located, and tissue samples are collected.

Needle Biopsy:

- A sandbag may be placed under the abdomen to aid in moving the kidneys to the desired position. Direct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes. Instruct the patient to take a deep breathe, exhale forcefully, and hold the breathe while the biopsy needle is inserted and rotated to obtain a core of renal tissue. Once the needle is removed, the patient may breathe. Pressure is applied to the site for 5 to 20 min, then a sterile pressure dressing is applied.

General:

- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- Place tissue samples in formalin solution. Label the specimen, indicating site location, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed. Instruct the patient to immediately report symptoms such as backache, flank pain, shoulder pain, lightheadedness, burning on urination, hematuria, chills, or fever, which may indicate the presence of infection, hemorrhage, or inadvertent puncture of other internal organs. Observe the patient for other signs of distress, including hypotension and tachycardia.
- Inform the patient that blood may be seen in the urine after the first or second postprocedural voiding.
- Monitor fluid intake and output for 24 hr. Instruct the patient on intake and output recording and provide appropriate measuring containers.
- Instruct the patient to report any changes in urinary pattern or volume or any unusual appearance of the urine. If urinary volume is less than 200 mL in the first 8 hr, encourage the patient to increase fluid intake unless contraindicated by another medical condition.
- Assess for nausea and pain.
- Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for removal of sutures, if

indicated. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change

in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include albumin, aldosterone, angiography renal, antibodies, anti-glomerular basement membrane, β_2 -microglobulin, BUN, CT renal, creatinine, creatinine clearance, cytology urine, cystoscopy, IVP, KUB studies, osmolality, PTH, potassium, protein, renin, renogram, sodium, US kidney, and UA.
- ▶ Refer to the Genitourinary and Immune System tables at the back of the book for related tests by body system.

Biopsy, Liver

SYNONYM/ACRONYM: N/A.

SPECIMEN: Liver tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue)
No abnormal cells or tissue.

DESCRIPTION: Liver biopsy is the excision of a tissue sample from the liver for microscopic analysis to determine cell morphology and the presence of tissue abnormalities. This test is used to assist in confirming a diagnosis of cancer or certain disorders of the hepatic parenchyma. Biopsy specimen is usually obtained either percutaneously or after surgical incision.

INDICATIONS:

- Assist in confirming suspected hepatic malignancy
- Assist in confirming suspected hepatic parenchymal disease

- Assist in diagnosing the cause of persistently elevated liver enzymes, hepatomegaly, or jaundice

RESULT:

Positive findings in:


- Benign tumor
- Cancer
- Cholesterol ester storage disease
- Cirrhosis
- Galactosemia
- Hemochromatosis
- Hepatic involvement with systemic lupus erythematosus, sarcoidosis, or amyloidosis
- Hepatitis
- Parasitic infestations (e.g., amebiasis, malaria, visceral larva migrans)

- Reye's syndrome
- Wilson's disease

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  This procedure is contraindicated in patients with bleeding disorders, suspected vascular tumor of the liver, ascites that may obscure proper insertion site for needle biopsy, subdiaphragmatic or right hemothoracic infection, or biliary tract infection.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to establish a diagnosis of liver disease.
- ▶ Obtain a history of the patient's complaints, especially fatigue and pain related to inflammation and swelling of the liver. Include a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's hepatobiliary and immune system, especially any bleeding disorders and other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications including anticoagulants,

aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.

- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; a general anesthesia will be administered prior to the open biopsy. Explain to the patient that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a HCP specializing in this procedure. The surgical procedure usually takes about 90 min to complete, and sutures may be necessary to close the site. A needle biopsy usually takes about 15 min to complete.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.

Open Biopsy:

- ▶ Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.

Needle Biopsy:

- ▶ Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.

General:

- ▶ *Make sure a written and informed consent has been signed prior to the*

procedure and before administering any medications.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 4 to 8 hr depending on the anesthetic chosen for the procedure.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Have the patient void before the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Assist the patient to the desired position depending on the test site to be used and direct the patient to breathe normally during the beginning of the general anesthetic. Instruct the patient to cooperate fully and to follow directions. For the patient undergoing local anesthesia, direct him or her to breathe normally and to avoid unnecessary movement during the procedure. Instruct the patient to avoid coughing or straining, as this may increase intra-abdominal pressure.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Open Biopsy:

- ▶ After administration of general anesthesia and surgical prep are completed, an incision is made, suspicious area(s) are located, and tissue samples are collected.

Needle Biopsy:

- ▶ Direct the patient to take slow deep breaths when the local anesthetic is

injected. Protect the site with sterile drapes. Instruct the patient to take a deep breathe, exhale forcefully, and hold the breathe while the biopsy needle is inserted and rotated to obtain a core of liver tissue. Once the needle is removed, the patient may breathe. Pressure is applied to the site for 3 to 5 min, then a sterile pressure dressing is applied.

General:

- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ▶ Place tissue samples in formalin solution. Label the specimen, indicating site location, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed. Instruct the patient to immediately report any pleuritic pain, persistent right shoulder pain, or abdominal pain.
- ▶ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as

directed by the health care practitioner.

- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for removal of sutures, if indicated. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the

patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, albumin, ALP, ammonia, amylase, AMA/ASMA, α_1 -antitrypsin/phenotyping, AST, bilirubin, cholesterol, coagulation factors, complete blood count, copper, GGT, hepatitis antigens and antibodies, infectious mononucleosis screen, laparoscopy abdominal, lipase, liver and spleen scan, MRI liver, PT/INR, radiofrequency ablation liver, UA, and US liver.
- ▶ Refer to the Hepatobiliary and Immune System tables at the end of the book for related tests by body system.

Biopsy, Lung

SYNONYM/ACRONYM: Transbronchial lung biopsy, open lung biopsy.

SPECIMEN: Lung tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue) No abnormal tissue or cells; no growth in culture.

DESCRIPTION: A biopsy of the lung is performed to obtain lung tissue for examination of pathologic features. The specimen can be obtained transbronchially or by open lung biopsy. In a

transbronchial biopsy, forceps pass through the bronchoscope to obtain the specimen. In a transbronchial needle aspiration biopsy, a needle passes through a bronchoscope to obtain the

specimen. In a transcatheter bronchial brushing, a brush is inserted through the bronchoscope. In an open lung biopsy, the chest is opened and a small thoracic incision is made to remove tissue from the chest wall. Lung biopsies are used to differentiate between infection and other sources of disease indicated by initial radiology studies, computed tomography scans, or sputum analysis. Specimens are cultured to detect pathogenic organisms or directly examined for the presence of malignant cells.

INDICATIONS:

- Assist in the diagnosis of lung cancer
- Assist in the diagnosis of fibrosis and degenerative or inflammatory diseases of the lung
- Assist in the diagnosis of sarcoidosis

RESULT:

Abnormal findings in:

- Amyloidosis
- Cancer
- Granulomas
- Infections caused by *Blastomyces*, *Histoplasma*, *Legionella* spp., and *Pneumocystis jiroveci* (formerly *carinii*)
- Sarcoidosis
- Systemic lupus erythematosus
- Tuberculosis



CRITICAL VALUES:

- Shortness of breathe, cyanosis, or rapid pulse during the procedure must be reported immediately.
- Any postprocedural decrease in breathe sounds noted at the biopsy site should be reported immediately.

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing

of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  Conditions such as vascular anomalies of the lung, bleeding abnormalities, or pulmonary hypertension may increase the risk of bleeding.
-  Conditions such as bullae or cysts and respiratory insufficiency increase the risk of pneumothorax.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to establish a diagnosis of lung disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's immune and respiratory systems, any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be

administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the transbronchial needle aspiration biopsy; a general anesthesia will be administered prior to the open biopsy. Explain to the patient that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Atropine is usually given before bronchoscopy examinations to reduce bronchial secretions and prevent vagally induced bradycardia. Meperidine (Demerol) or morphine may be given as a sedative. Lidocaine is sprayed in the patient's throat to reduce discomfort caused by the presence of the tube. Inform the patient that the biopsy is performed under sterile conditions by a HCP specializing in this procedure. The surgical procedure usually takes about 30 min to complete, and sutures may be necessary to close the site. A needle biopsy usually takes about 15 to 30 min to complete.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, antibiotics, anesthetics, and analgesics.
- ▶ Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.
- ▶ Have the patient void before the procedure.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 6 to 8 hr prior to the procedure.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of

anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.

- ▶ Have emergency equipment readily available. Keep resuscitation equipment on hand in the case of respiratory impairment or laryngospasm after the procedure.
- ▶ Avoid using morphine sulfate in those with asthma or other pulmonary disease. This drug can further exacerbate bronchospasms and respiratory impairment.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location, especially left or right lung.
- ▶ Have patient remove dentures, contact lenses, eyeglasses, and jewelry. Notify the HCP if the patient has permanent crowns on teeth. Have the patient remove clothing and change into a gown for the procedure.
- ▶ Assist the patient to a comfortable position, and direct the patient to breathe normally during the beginning of the general anesthesia. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Record baseline vital signs and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Open Biopsy:

- ▶ The patient is prepared for thoracotomy under general anesthesia in the operating room. Tissue specimens are collected from suspicious sites. Place specimen from needle aspiration or brushing on clean glass microscope slides. Place tissue or aspirate specimens in appropriate sterile container for culture or appropriate fixative container for histological studies.
- ▶ Carefully observe the patient for any signs of respiratory distress during the procedure.

- ▶ A chest tube is inserted after the procedure.

Needle Biopsy:

- ▶ Instruct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes. Assist patient to a sitting position with arms on a pillow over a bed table. Instruct patient to avoid coughing during the procedure. The needle is inserted through the posterior chest wall and into the intercostal space. The needle is rotated to obtain the sample and then withdrawn. Pressure is applied to the site with a Vaseline gauze, and a pressure dressing is applied over the Vaseline gauze.

Bronchoscopy:

- ▶ Provide mouth care to reduce oral bacterial flora.
- ▶ After administration of general anesthesia, position the patient in a supine position with the neck hyperextended. If local anesthesia is used, the patient is seated while the tongue and oropharynx are sprayed and swabbed with anesthetic. Provide an emesis basin for the increased saliva and encourage the patient to spit out the saliva because the gag reflex may be impaired. When loss of sensation is adequate, the patient is placed in a supine or side-lying position. The fiberoptic scope can be introduced through the nose, the mouth, an endotracheal tube, a tracheostomy tube, or a rigid bronchoscope. Most common insertion is through the nose. Patients with copious secretions or massive hemoptysis, or in whom airway complications are more likely, may be intubated before the bronchoscopy. Additional local anesthetic is applied through the scope as it approaches the vocal cords and the carina, eliminating reflexes in these sensitive areas. The fiberoptic approach allows visualization of airway segments without having to move the patient's head through various positions.
- ▶ After visual inspection of the lungs, tissue samples are collected from suspicious sites by bronchial brush or biopsy forceps to be used for cytologic and microbiologic studies.

- ▶ After the procedure, the bronchoscope is removed. Patients who had local anesthesia are placed in a semi-Fowler's position to recover.

General:

- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ▶ Place tissue samples in properly labeled specimen containers containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- ▶ Inform the patient that he or she may experience some throat soreness and hoarseness. Instruct patient to treat throat discomfort with lozenges and warm gargles when the gag reflex returns.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Emergency resuscitation equipment should be readily available if the vocal cords become spastic after intubation.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- ▶ Observe the patient for hemoptysis, difficulty breathing, cough, air hunger, excessive coughing, pain, or absent breathe sounds over the affected area. Report to HCP. Monitor chest tube patency and drainage after a thoracotomy.
- ▶ Evaluate the patient for symptoms indicating the development of

pneumothorax, such as dyspnea, tachypnea, anxiety, decreased breathing sounds, or restlessness. A chest x-ray may be ordered to check for the presence of this complication.

- ▶ Evaluate the patient for symptoms of empyema, such as fever, tachycardia, malaise, or elevated white blood cell count.
- ▶ Observe the patient's sputum for blood if a biopsy was taken, because large amounts of blood may indicate the development of a problem; a small amount of streaking is expected. Evaluate the patient for signs of bleeding, such as tachycardia, hypotension, or restlessness.
- ▶ Instruct the patient in the care and assessment of the biopsy site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to keep the site clean and change the dressing as needed.
- ▶ Instruct the patient to remain in a semi-Fowler's position after bronchoscopy or fine needle aspiration to maximize ventilation. Semi-Fowler's position is a semisitting position with the knees flexed and supported by pillows on the bed or examination table. Instruct the patient to stay in bed lying on the affected side for at least 2 hr with a pillow or rolled towel under the site to prevent bleeding. The patient will also need to remain on bed rest for 24 hr.
- ▶ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient to use lozenges or gargle for throat discomfort. Inform the patient of smoking cessation programs as appropriate. Malnutrition is commonly seen in patients with severe respiratory disease for numerous reasons, including fatigue, lack of appetite, and gastrointestinal distress. Adequate intake of vitamins A and C are also important to prevent pulmonary infection and to decrease the extent of lung tissue damage. The importance of following the prescribed diet should be stressed to the patient/caregiver. Educate the patient regarding access to counseling services, as appropriate. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include arterial/alveolar oxygen ratio, antibodies, anti-glomerular basement membrane, blood gases, bronchoscopy, chest x-ray, complete blood count, CT thoracic, culture sputum, cytology sputum, gallium scan, gram/acid fast stain, lung perfusion scan, lung ventilation scan, MRI chest, mediastinoscopy, pleural fluid analysis, PFT, and TB skin tests.
- ▶ Refer to the Immune and Respiratory System tables at the back of the book for related tests by body system.

Biopsy, Lymph Node

B

SYNONYM/ACRONYM: N/A

SPECIMEN: Lymph node tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue) No abnormal tissue or cells.

DESCRIPTION: Lymph node biopsy is the excision of a tissue sample from one or more lymph nodes for microscopic analysis to determine cell morphology and the presence of tissue abnormalities. This test assists in confirming a diagnosis of cancer, diagnosing disorders causing systemic illness, or determining the stage of metastatic cancer. A biopsy specimen is usually obtained either by needle biopsy or after surgical incision. Biopsies are most commonly performed on the following types of lymph nodes: cervical nodes, which drain the face and scalp; axillary nodes, which drain the arms, breasts, and upper chest; and inguinal nodes, which drain the legs, external genitalia, and lower abdominal wall.

INDICATIONS:

- Assist in confirming suspected fungal or parasitic infections of the lymphatics
- Assist in confirming suspected malignant involvement of the lymphatics
- Determine the stage of metastatic cancer
- Differentiate between benign and malignant disorders that may cause lymph node enlargement

- Evaluate persistent enlargement of one or more lymph nodes for unknown reasons

RESULT:


Abnormal findings in:

- Chancroid
- Fungal infection (e.g., cat scratch disease)
- Immunodeficiency
- Infectious mononucleosis
- Lymph involvement of systemic diseases (e.g., systemic lupus erythematosus, sarcoidosis)
- Lymphangitis
- Lymphogranuloma venereum
- Malignancy (e.g., lymphomas, leukemias)
- Metastatic disease
- Parasitic infestation (e.g., pneumoconiosis)

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  This procedure is contraindicated in patients with bleeding disorders.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to establish a diagnosis of lymph node disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's immune and musculoskeletal systems, any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; a general anesthesia will be administered prior to the open biopsy. Explain to the patient that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a HCP, specializing in this procedure, with support staff. The surgical procedure usually takes about 30 min to complete, and sutures may be necessary to

close the site. A needle biopsy usually takes about 15 min to complete.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.

Open Biopsy:

- ▶ Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.

Needle Biopsy:

- ▶ Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.

General:

- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 4 to 8 hr depending on the anesthetic chosen for the procedure.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Have the patient void before the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Assist the patient to the desired position depending on the test site to be used and direct the patient to breathe normally during the beginning of the general anesthetic. Instruct the patient to cooperate fully and to follow

directions. For the patient undergoing local anesthesia, direct him or her to breathe normally and to avoid unnecessary movement during the procedure.

- Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Open Biopsy:

- After administration of general anesthesia and surgical prep are completed, an incision is made, suspicious area(s) are located, and tissue samples are collected.

Needle Biopsy:

- Instruct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes. The node is grasped with sterile gloved fingers, and a needle (with attached syringe) is inserted directly into the node. The node is aspirated to collect the specimen. Pressure is applied to the site for 3 to 5 min, then a sterile dressing is applied.

General:

- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- Place tissue samples in formalin solution. Label the specimen, indicating site location, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature

is elevated. Protocols may vary from facility to facility.

- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed.
- Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for removal of sutures, if indicated. Answer any questions or address any concerns voiced by the patient or family.
- Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in

relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include biopsy bone marrow, CD4/ CD8 enumeration, cerebrospinal fluid analysis, *Chlamydia* serology, complete blood count, CT pelvis, CT thoracic, culture for bacteria/fungus, CMV, gram stain, HIV-1/HIV-2 serology, immunofixation

electrophoresis, immunoglobulins A, G, and M, infectious mononucleosis screen, lymphangiography, mamogram, mediastinoscopy, PET pelvis, RF, total protein and fractions, toxoplasmosis serology, and US lymph nodes.

Refer to the Immune and Musculoskeletal System tables at the back of the book for related tests by body system.

B

Biopsy, Muscle

SYNONYM/ACRONYM: N/A

SPECIMEN: Muscle tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue) No abnormal tissue or cells.

DESCRIPTION: Muscle biopsy is the excision of a muscle tissue sample for microscopic analysis to determine cell morphology and the presence of tissue abnormalities. This test is used to confirm a diagnosis of neuropathy or myopathy and to diagnose parasitic infestation. A biopsy specimen is usually obtained from the deltoid or gastrocnemius muscle after a surgical incision.

INDICATIONS:

- Assist in confirming suspected fungal infection or parasitic infestation of the muscle
- Assist in diagnosing the cause of neuropathy or myopathy
- Assist in the diagnosis of Duchenne's muscular dystrophy

RESULT:

Abnormal findings in:

- Alcoholic myopathy
- Amyotrophic lateral sclerosis
- Duchenne's muscular dystrophy
- Fungal infection
- Myasthenia gravis
- Myotonia congenita
- Parasitic infestation
- Polymyalgia rheumatica
- Polymyositis

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

- If electromyography is performed before muscle biopsy, residual

inflammation may lead to false-positive biopsy results.

- ◆ This procedure is contraindicated in patients with bleeding disorders.
- ◆ Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to establish a diagnosis of musculoskeletal disease.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ◆ Obtain a history of the patient's immune and musculoskeletal systems, any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ◆ Note any recent procedures that can interfere with test results.
- ◆ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ◆ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; a general anesthesia will be administered prior to the open

biopsy. Explain that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a HCP specializing in this procedure. The surgical procedure usually takes about 20 min to complete, and sutures may be necessary to close the site. A needle biopsy usually takes about 15 min to complete.

- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives.
- ◆ Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.
- ◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ◆ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 4 hr prior to the procedure.
- ◆ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ◆ Have emergency equipment readily available.
- ◆ Have the patient void before the procedure.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ◆ Assist the patient to a comfortable position: a supine position (for deltoid biopsy) or prone position (for

gastrocnemius biopsy). Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.

- Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.

Open Biopsy:

- Assess baseline neurologic status. Instruct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes.
- After infiltration of the site with local anesthetic, a small incision is made through the dermis, exposing the muscle. A small area of muscle is excised and removed with forceps. The area is then closed with sutures or similar material, and a sterile dressing is applied.

Needle Biopsy:

- Instruct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes.
- After infiltration of the site with local anesthetic, a cutting biopsy needle is introduced through a small skin incision and bored into the muscle. A core needle is introduced through the cutting needle, and a plug of muscle is removed. The needles are withdrawn, and the specimen is placed in a preservative solution. Pressure is applied to the site for 3 to 5 min, and then a pressure dressing is applied.

General:

- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- Place tissue samples in properly labeled specimen container containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.

- Instruct the patient to resume preoperative diet, as directed by the HCP.
- Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed.
- Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for removal of sutures, if indicated. Answer any questions or address any concerns voiced by the patient or family.
- Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy

regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.

- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in

relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include AChR, aldolase, ANA, antibody Jo-1, antithyroglobulin antibodies, CK and isoenzymes, EMG, ENG, myoglobin, and RF.
- Refer to the Immune and Musculoskeletal System tables at the back of the book for related tests by body system.

Biopsy, Prostate

SYNONYM/ACRONYM: N/A

SPECIMEN: Prostate tissue.

REFERENCE VALUE: (Method: Microscopic examination of tissue cells) No abnormal cells or tissue.

DESCRIPTION: Biopsy of the prostate gland is performed to identify cancerous cells, especially if serum prostate-specific antigen is increased.

INDICATIONS:

- Evaluate prostatic hypertrophy of unknown etiology
- Investigate suspected cancer of the prostate

RESULT: Positive findings in prostate cancer.

Gleason Grading

- Simple round glands, closely packed rounded masses with well-defined edges. Closely resemble normal prostate tissue.
- Simple round glands, loosely packed in vague, rounded masses with loosely packed edges. Closely resemble normal prostate tissue.
- Small, very small, or medium-sized single glands of irregular shape and spacing with poorly defined infiltrating edges.
- Small, medium, or large glands fused into cords, chains, or ragged infiltrating masses.
- No glandular differentiation, solid sheets, cords, single cells with central necrosis.

The Gleason Score is the sum of 2 grades assigned by the pathologist during microscopic examination of the biopsy samples. The score ranges from 1–10 with 10 being the worst. The first number assigned is the primary grade (1–5), which indicates where the cancer is the most prominent. The second number is the secondary grade (1–5), which indicates where the cancer is next most prominent. It is important to have the breakdown in grading as well as the total score. For example Patient A's Gleason Score is $4 + 3 = 7$ and Patient B's Gleason Score is $3 + 4 = 7$. Even though both patients have the same Gleason Score, Patient B has a slightly better prognosis because the primary area is graded a 3.

TNM Classification of Tumors

T Refers to the size of the Primary Tumor

- T₀ No evidence of primary tumor
- T_{is} Carcinoma in situ
- T₁₋₄ Increasing degrees in tumor size and involvement

N refers to Lymph Node Involvement

- N₀ No evidence of disease in lymph nodes
- N₁₋₄ Increasing degrees in lymph node involvement
- N_x Regional lymph nodes unable to be assessed clinically



M refers to Distant Metastases

- M₀ No evidence of distant metastases
- M₁₋₄ Increasing degrees of distant metastatic involvement, including distant nodes

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  This procedure is contraindicated in patients with bleeding disorders.
-  Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- The various sampling approaches have individual drawbacks that should be considered: transurethral sampling does not always ensure that malignant cells will be included in the specimen, whereas transrectal sampling carries the risk of perforating the rectum and creating a chan-

nel through which malignant cells can seed normal tissue.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to establish a diagnosis of prostate disease.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ♦ Obtain a history of the patient's genitourinary and immune systems, any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications including anticoagulants,

aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.

- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; a general anesthesia will be administered prior to the open biopsy. Explain to the patient that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a HCP, with support staff, specializing in this procedure. The surgical procedure usually takes about 30 min to complete, and sutures may be necessary to close the site. A needle biopsy usually takes about 20 min to complete.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, antibiotics, anesthetics, and analgesics.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ▶ Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that

food has been restricted for at least 6 to 8 hr prior to the procedure.

- ▶ Have emergency equipment readily available.
- ▶ Have the patient void before the procedure. Administer enemas if ordered.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Assist the patient to a comfortable position, and direct the patient to breathe normally during the beginning of the general anesthesia.
- ▶ Cleanse the biopsy site with an antiseptic solution, and drape the area with sterile towels.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.

Transurethral Approach:

- ▶ After administration of general anesthesia, position the patient on a urologic exam table with the feet in stirrups. The endoscope is inserted into the urethra. The tissue is excised with a cutting loop and is placed in formalin solution.

Transrectal Approach:

- ▶ After administration of general anesthesia, position the patient in the Sims' position. A rectal examination is performed to locate suspicious nodules. A biopsy needle guide is placed at the biopsy site, and the biopsy needle is inserted through the needle guide. The cells are aspirated, the needle is withdrawn, and the sample is placed in formalin solution.

Perineal Approach:

- ▶ After administration of general anesthesia, position the patient in the lithotomy position. Clean the perineum with an antiseptic solution, and protect the biopsy site with sterile drapes. A small incision is made and the sample is removed by needle biopsy or biopsy punch and placed in formalin solution.

General:

- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).

- ▶ Apply digital pressure to the biopsy site. If there is no bleeding after the perineal approach, place a sterile dressing on the biopsy site. Immediately notify the HCP if there is significant bleeding.
- ▶ Place tissue samples in properly labeled specimen containers containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Monitor fluid intake and output for 24 hr. Instruct the patient on intake and output recording and provide appropriate measuring containers.
- ▶ Encourage fluid intake of 3000 mL, unless contraindicated.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the perineal approach biopsy site for bleeding, inflammation, or hematoma formation. Instruct the patient to keep the site clean and change the dressing as needed.
- ▶ Instruct the patient to immediately report pain, chills, or fever. Assess for infection, hemorrhage, or perforation of the urethra or rectum.
- ▶ Inform the patient that blood may be seen in the urine after the first or second postprocedural voiding.
- ▶ Instruct the patient to report any further changes in urinary pattern, volume, or appearance.
- ▶ Assess for nausea, pain, and bladder spasms. Administer antiemetic, analgesic, and antispasmodic

medications as needed and as directed by the HCP.

- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the National Cancer Institute (www.cancer.gov).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Counsel the patient, as appropriate, that sexual dysfunction related to altered body function, drugs, or radiation may occur. Educate the patient regarding access to counseling services, as appropriate. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include cystoscopy, cystourethrography voiding, PAP, PSA, retrograde ureteropyelography, semen analysis, and US prostate.
- ▶ Refer to the Genitourinary and Immune System tables at the back of the book for related tests by body system.

Biopsy, Skin

B

SYNONYM/ACRONYM: N/A

SPECIMEN: Skin tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue)
No abnormal tissue or cells.

DESCRIPTION: Skin biopsy is the excision of a tissue sample from suspicious skin lesions. The microscopic analysis can determine cell morphology and the presence of tissue abnormalities. This test assists in confirming the diagnosis of malignant or benign skin lesions. A skin biopsy can be obtained by any of these four ways: curettage, shaving, excision, or punch. A Tzanck (Tsanck) smear may be prepared from vesicles (blisters) present on the skin. Skin cells in the vesicles can be evaluated microscopically to indicate the presence of certain viruses, especially herpes, that cause cells to become enlarged and otherwise abnormal in appearance.

INDICATIONS:

- Assist in the diagnosis of keratoses, warts, moles, keloids, fibromas, cysts, or inflamed lesions
- Assist in the diagnosis of inflammatory process of the skin, especially herpes infection
- Assist in the diagnosis of skin cancer
- Evaluate suspicious skin lesions

RESULT:

Abnormal findings in:


- Basal cell carcinoma
- Cysts
- Dermatitis

- Dermatofibroma
- Keloids
- Malignant melanoma
- Neurofibroma
- Pemphigus
- Pigmented nevi
- Seborrheic keratosis
- Skin involvement in systemic lupus erythematosus, discoid lupus erythematosus, and scleroderma
- Squamous cell carcinoma
- Viral infection (herpes, varicella)
- Warts

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  This procedure is contraindicated in patients with bleeding disorders.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to establish a diagnosis of skin disease.
 - ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
 - ▶ Obtain a history of the patient's immune and musculoskeletal systems, any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
 - ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
 - ▶ Note any recent procedures that can interfere with test results.
 - ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
 - ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the punch biopsy; a general anesthesia will be administered prior to the open biopsy. Explain that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a punch biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient the biopsy is performed under sterile conditions by a HCP, with support staff, specializing in this procedure. The surgical procedure usually takes about 30 min to complete, and sutures may be necessary to close the site. A punch biopsy usually takes about 20 min to complete.
 - ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
 - ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives, depending on the type of biopsy.
 - ▶ There are no food, fluid, or medication restrictions unless by medical direction.
 - ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- INTRATEST:**
- ▶ Ensure that the patient has complied with dietary restrictions, if ordered by the HCP.
 - ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
 - ▶ Have emergency equipment readily available.
 - ▶ Have the patient void before the procedure.
 - ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
 - ▶ Assist the patient to the desired position depending on the test site to be used, and direct the patient to breathe normally during the local anesthetic and the procedure. Instruct the patient to cooperate fully, follow directions and avoid unnecessary movement.
 - ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
 - ▶ After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.
 - ▶ **Curettage:** The skin is scraped with a curette to obtain specimen.
 - ▶ **Shaving or excision:** A scalpel is used to remove a portion of the lesion that protrudes above the epidermis. If the lesion is to be excised, the incision is

made as wide and as deep as needed to ensure that the entire lesion is removed. Bleeding is controlled with external pressure to the site. Large wounds are closed with sutures. An adhesive bandage is applied when excision is complete.

- ▶ **Punch biopsy:** A small, round punch about 4 to 6 mm in diameter is rotated into the skin to the desired depth. The cylinder of skin is pulled upward with forceps and separated at its base with a scalpel or scissors. If needed, sutures are applied. A sterile dressing is applied over the site.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ▶ Place tissue samples in properly labeled specimen container containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed.

- ▶ Assess for nausea and pain.
- ▶ Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for the removal of sutures, if indicated. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include allergen-specific IgE, ANA, culture skin, eosinophil count, ESR, and IgE.
- ▶ Refer to the Immune and Musculoskeletal System tables at the back of the book for related tests by body system.

Biopsy, Thyroid

B

SYNONYM/ACRONYM: N/A

SPECIMEN: Thyroid gland tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue) No abnormal tissue or cells.

DESCRIPTION: Thyroid biopsy is the excision of a tissue sample for microscopic analysis to determine cell morphology and the presence of tissue abnormalities. This test assists in confirming a diagnosis of cancer or determining the cause of persistent thyroid symptoms. A biopsy specimen can be obtained by needle aspiration or by surgical excision.

INDICATIONS:

- Assist in the diagnosis of thyroid cancer or benign cysts or tumors
- Determine the cause of inflammatory thyroid disease
- Determine the cause of hyperthyroidism
- Evaluate enlargement of the thyroid gland

RESULT:

Positive findings in:


- Benign thyroid cyst
- Granulomatous thyroiditis
- Hashimoto's thyroiditis
- Nontoxic nodular goiter
- Thyroid cancer

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing

of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

-  This procedure is contraindicated in patients with bleeding disorders.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to establish a diagnosis of thyroid disease.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ♦ Obtain a history of the patient's endocrine and immune systems, any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Record the date of the last menstrual period and determine possibility of pregnancy in perimenopausal women.
- ♦ Note any recent procedures that can interfere with test results.

- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals. Such products be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to the percutaneous biopsy; general anesthesia will be administered prior to the open biopsy. Explain that no pain will be experienced during the test when general anesthesia is used, but that any discomfort with a needle biopsy will be minimized with local anesthetics and systemic analgesics. Inform the patient that the biopsy is performed under sterile conditions by a HCP, with support staff, specializing in this procedure. The surgical procedure usually takes about 30 min to complete, and that sutures may be necessary to close the site. A needle biopsy usually takes about 15 min to complete.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.

Open Biopsy:

- ▶ Instruct the patient that nothing should be taken by mouth for 6 to 8 hr prior to a general anesthetic. Protocols may vary from facility to facility.

Needle Biopsy:

- ▶ Instruct the patient that nothing should be taken by mouth for at least 4 hr prior to the procedure to reduce the risk of nausea and vomiting. Protocols may vary from facility to facility.
- ▶ Have the patient void before the procedure.

General:

- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure food has been restricted for at least 4 to 8 hr depending on the anesthetic chosen for the procedure.
 - ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependant on the type of anticoagulant. Notify HCP if patient anticoagulant therapy has not been withheld.
 - ▶ Have emergency equipment readily available.
 - ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
 - ▶ Assist the patient to the desired position depending on the test site to be used and direct the patient to breathe normally during the beginning of the general anesthetic. Instruct the patient to cooperate fully and to follow directions. For the patient undergoing local anesthesia, direct him or her to breathe normally and to avoid unnecessary movement during the procedure.
 - ▶ Record baseline vital signs and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
 - ▶ After the administration of general or local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels.
- #### **Open Biopsy:**
- ▶ After administration of general anesthesia and surgical prep is completed, an incision is made, suspicious area(s) are located, and tissue samples are collected.

Needle Biopsy:

- Direct the patient to take slow deep breaths when the local anesthetic is injected. Protect the site with sterile drapes. Instruct the patient to take a deep breathe, exhale forcefully, and hold the breathe while the biopsy needle is inserted and rotated to obtain a core of breast tissue. Once the needle is removed, the patient may breathe. Pressure is applied to the site for 3 to 5 min, then a sterile pressure dressing is applied.

General:

- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- Place tissue samples in properly labeled specimen container containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP who will discuss the results with the patient.
- Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Notify the HCP if elevated temperature. Protocols may vary from facility to facility.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed.

- Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Recognize anxiety related to test. Discuss the implications of the abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of a follow-up appointment for removal of sutures, if indicated. Answer any questions or address any concerns voiced by the patient or family.
- Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antibodies, antithyroglobulin, calcitonin and stimulation tests, parathyroid scan, radioactive iodine uptake, thyroid-binding inhibitory immunoglobulin, thyroid scan, TSH, free thyroxine, and US thyroid.
- Refer to the Endocrine and Immune System tables at the back of the book for related tests by body system.

Bladder Cancer Markers, Urine

B

SYNONYM/ACRONYM: Nuclear Matrix Protein (NMP) 22, Bard BTA, cytogenic marker for bladder cancer.

SPECIMEN: Urine (5 mL), unpreserved random specimen collected in a clean plastic collection container for NMP22 and Bard BTA), Urine (30 mL), first void specimen collected in fixative specific for FISH testing.

REFERENCE VALUE: (Method: Enzyme immunoassay for NMP22, immunochromatographic for Bard BTA, Fluorescence in situ Hybridization (FISH) for cytogenic marker)

NMP22: Negative: Less than 6 units/mL, Borderline: 6–10 units/mL, Positive: Greater than 10 units/mL

Bard BTA: Negative

Cytogenic Marker: Negative

DESCRIPTION: Cystoscopy is still considered the gold standard for detection of bladder cancer, but other noninvasive tests are being developed, including several urine assays approved by the Food and Drug Administration. Compared to cytologic studies, these assays are believed to be more sensitive but less specific for detecting transitional cell carcinoma. FISH is a cytogenic technique that uses fluorescent-labeled DNA probes to detect specific chromosome abnormalities. The FISH bladder cancer assay specifically detects the presence of aneuploidy for chromosomes 3, 7, 17, and absence of the 9p21 loci; findings associated with transitional cell cancer of the bladder.

NMP22: Nuclear matrix proteins (NMPs) are involved in the regulation and expression of various genes. The NMP identified as NuMA is abundant in bladder tumor cells. The dying tumor cells release the soluble NMP into the urine. This assay is quantitative.

Bladder tumor antigen (BTA):

A human complement factor H-related protein (hCFHrp) is thought to be produced by bladder tumor cells as protection from the body's natural immune response. BTA is released from tumor cells into the urine. This assay is qualitative.

INDICATIONS:

- Detection of bladder carcinoma
- Management of recurrent bladder cancer

RESULT: *Increased in bladder carcinoma.*

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- **NMP22:** Any condition that results in inflammation of the bladder or urinary tract may cause falsely elevated values.
- **Bard BTA:** Recent surgery, biopsy, or other trauma to the bladder or urinary tract may cause falsely elevated values. Bacterial overgrowth from active urinary

tract infection, renal or bladder calculi, gross contamination from blood, and positive leukocyte dipstick may also cause false-positive results.

- **Cytogenic marker:** Incorrect fixative, gross contamination from blood, bacterial overgrowth from active urinary tract infection, inadequate number of bladder cells in specimen.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to diagnose bladder cancer.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's genitourinary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there should be no discomfort during the procedure. Inform the patient that specimen collection takes approximately 5 min, depending on the cooperation and ability of the patient.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
- ▶ Obtain urine specimen in a clean plastic collection container. Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bladder, cytology urine, cystoscopy, and US bladder.
- ▶ Refer to the Genitourinary and Immune System tables at the back of the book for related tests by body system.

Bleeding Time

B

SYNONYM/ACRONYM: Mielke bleeding time, Simplate bleeding time, Template bleeding time, Surgicutt, Ivy bleeding time.

SPECIMEN: Whole blood.

REFERENCE VALUE: (Method: Timed observation of incision)

Template: 2.5 to 10 min

Ivy: 2 to 7 min

There are slight differences in the disposable devices used to make the incision. Although the Mielke or Template bleeding time is believed to offer greater standardization to a fairly subjective procedure, both methods are thought to be of equal sensitivity and reproducibility.

RESULT:

This test does not predict excessive bleeding during a surgical procedure.

Prolonged in:

- Bernard-Soulier syndrome (*rare hereditary condition in which platelet glycoprotein GPIb is deficient and platelet aggregation is decreased*)
- Fibrinogen disorders (*fibrinogen helps platelets link together*)
- Glanzmann's thrombasthenia (*rare hereditary condition in which platelet glycoprotein IIb/IIIa is deficient and platelet aggregation is decreased*)
- Hereditary telangiectasia (*fragile blood vessels do not permit adequate constriction to stop bleeding*)

- Liver disease (*any condition that affects the production of coagulation proteins will affect bleeding time*)
- Some myeloproliferative disorders (*where production of platelets is decreased*)
- Renal disease (*abnormal platelet function*)
- Thrombocytopenia (*insufficient platelets to stop bleeding*)
- von Willebrand's disease (*deficiency of von Willebrand factor, necessary for normal platelet adhesion*)

Decreased in: N/A

CRITICAL VALUES:

Greater than 14 min

Note and immediately report to the health care practitioner (HCP) any critically increased values and related symptoms.

Find and print out the full monograph at [DavisPlus \(davisplus.fadavis.com, keyword Van Leeuwen\)](http://DavisPlus(davisplus.fadavis.com, keyword Van Leeuwen)).

Blood Gases

B

SYNONYM/ACRONYM: Arterial blood gases (ABGs), venous blood gases, capillary blood gases, cord blood gases.

SPECIMEN: Whole blood. Specimen volume and collection container may vary with collection method. See Intratest section for specific collection instructions. Specimen should be tightly capped and transported in an ice slurry.

REFERENCE VALUE: (Method: Selective electrodes for pH, pCO₂ and pO₂)

Blood Gas Value (pH)	Birth, Cord, Full Term	Adult/Child
Arterial	7.11–7.36	7.35–7.45
Venous	7.25–7.45	7.32–7.43
Capillary	7.32–7.49	7.35–7.45
Scalp	7.25–7.40	N/A

SI units (conversion factor × 1).

pCO ₂	SI Units (Conventional Units × 0.133)		SI Units (Conventional Units × 0.133)		SI Units (Conventional Units × 0.133)	
	Arterial	Venous	Arterial	Venous	Capillary	Capillary
Birth, cord, full term	32–66 mm Hg	27–49 mm Hg	4.3–8.8 kPa	3.6–6.5 kPa	—	—
Adult/child	35–45 mm Hg	41–51 mm Hg	4.66–5.98 kPa	5.4–6.8 kPa	26–41 mm Hg	3.5–5.4 kPa

pO ₂	SI Units (Conventional Units × 0.133)		SI Units (Conventional Units × 0.133)		SI Units (Conventional Units × 0.133)	
	Arterial	Venous	Arterial	Venous	Capillary	Capillary
Birth, cord, full term	8–24 mm Hg	17–41 mm Hg	1.1–3.2 kPa	2.3–5.4 kPa	—	—
Adult/child	80–95 mm Hg	20–49 mm Hg	10.6–12.6 kPa	2.6–6.5 kPa	80–95 mm Hg	10.6–12.6 kPa

HCO_3^-	Arterial SI Units mmol/L (Conventional Units \times 1)	Venous SI Units mmol/L (Conventional Units \times 1)	Capillary SI Units mmol/L (Conventional Units \times 1)
Birth, cord, full term	17–24 mEq/L	17–24 mEq/L	N/A
Adult/child	18–23 mEq/L	24–28 mEq/Lq	18–23 mEq/L

O_2 Sat	Arterial	Venous	Capillary
Birth, cord, full term	40–90%	40–70%	—
Adult/child	95–99%	70–75%	95–98%

tCO_2	Arterial SI Units mmol/L (Conventional Units \times 1)	Venous SI Units mmol/L (Conventional Units \times 1)
Birth, cord, full term	13–22 mEq/L	14–22 mEq/L
Adult/child	22–29 mEq/L	25–30 mEq/Lq

BE Arterial	SI Units mmol/L (Conventional Units \times 1)
Birth, cord, full term	(–10) – (–2) mEq/L
Adult/child	(–2) – (+3) mEq/L

DESCRIPTION: Blood gas analysis is used to evaluate respiratory function and provide a measure for determining acid-base balance. Respiratory, renal, and cardiovascular system functions are integrated in order to maintain normal acid-base balance. Therefore, respiratory or metabolic disorders may cause abnormal blood gas findings. The blood gas measurements commonly reported are pH, partial pressure of carbon dioxide in the blood (pCO_2), partial pressure of oxygen in the blood (pO_2), bicarbonate (HCO_3^-), O_2 saturation, and base excess (BE)

or base deficit (BD). pH reflects the number of free hydrogen ions (H^+) in the body. A pH less than 7.35 indicates acidosis. A pH greater than 7.45 indicates alkalosis. Changes in the ratio of free hydrogen ions to bicarbonate will result in a compensatory response from the lungs or kidneys to restore proper acid-base balance.

pCO_2 is an important indicator of ventilation. The level of pCO_2 is controlled primarily by the lungs and is referred to as the respiratory component of acid-base balance. The main buffer system in the body is the

bicarbonate-carbonic acid system. Bicarbonate is an important alkaline ion that participates along with other anions such as hemoglobin, proteins, and phosphates to neutralize acids. For the body to maintain proper balance, there must be a ratio of 20 parts bicarbonate to one part carbonic acid (20:1). Carbonic acid level is indirectly measured by $p\text{CO}_2$. Bicarbonate level is indirectly measured by the total carbon dioxide content ($t\text{CO}_2$). The carbonic acid level is not measured directly, but can be estimated because it is 3% of the $p\text{CO}_2$. Bicarbonate can also be calculated from these numbers once the carbonic acid value has been obtained because of the 20:1 ratio. For example, if the $p\text{CO}_2$ were 40, the carbonic acid would be calculated as $(3\% \times 40)$ or 1.2, and the HCO_3^- would be calculated as (20×1.2) or 24. The main acid in the acid-base system is carbonic acid. It is the metabolic or nonrespiratory component of the acid-base system and is controlled by the kidney. Bicarbonate levels can either be measured directly or estimated from the $t\text{CO}_2$ in the blood. BE/BD reflects the number of anions available in the blood to help buffer changes in pH. A BD (negative BE) indicates metabolic acidosis, whereas a positive BE indicates metabolic alkalosis.

Extremes in acidosis are generally more life threatening than alkalosis. Acidosis can develop either very quickly (e.g., cardiac arrest) or over a longer period of time (e.g., renal failure). Infants can develop acidosis very quickly if they are not kept warm and given enough calories. Children with diabetes tend to go into

acidosis more quickly than do adults who have been dealing with the disease over a longer period of time. In many cases a venous or capillary specimen is satisfactory to obtain the necessary information regarding acid-base balance without subjecting the patient to an arterial puncture with its associated risks.

As seen in the table of reference ranges, $p\text{O}_2$ is lower in infants than in children and adults owing to the respective level of maturation of the lungs at birth. $p\text{O}_2$ tends to trail off after age 30, decreasing by approximately 3 to 5 mm Hg per decade as the organs age and begin to lose elasticity. There is a formula that can be used to approximate the relationship between age and $p\text{O}_2$:

$$p\text{O}_2 = 104 - (\text{age} \times 0.27)$$

Like carbon dioxide, oxygen is carried in the body in a dissolved and combined (oxyhemoglobin) form. Oxygen content is the sum of the dissolved and combined oxygen. The oxygen-carrying capacity of the blood indicates how much oxygen could be carried if all the hemoglobin were saturated with oxygen. Percent oxygen saturation is [oxyhemoglobin concentration divided by (oxyhemoglobin concentration + deoxyhemoglobin concentration)] times 100.

Testing on specimens other than arterial blood is often ordered when oxygen measurements are not needed or when the information regarding oxygen can be obtained by noninvasive techniques such as pulse oximetry. Capillary blood is satisfactory for most purposes for pH and

$p\text{CO}_2$; the use of capillary $p\text{O}_2$ is limited to the exclusion of hypoxia. Measurements involving oxygen are usually not useful when performed on venous samples; arterial blood is required to accurately measure $p\text{O}_2$ and oxygen saturation. There is considerable evidence that prolonged exposure to high levels of oxygen can result in injury, such as retinopathy of prematurity in infants or the drying of airways in any patient. Monitoring $p\text{O}_2$ from blood gases is especially appropriate under such circumstances.

INDICATIONS: This group of tests is used to assess conditions such as asthma, chronic obstructive pulmonary disease (COPD), embolism (e.g., fatty or other embolism) during coronary arterial bypass surgery, and

hypoxia. It is also used to assist in the diagnosis of respiratory failure, which is defined as a $p\text{O}_2$ less than 50 mm Hg and $p\text{CO}_2$ greater than 50 mm Hg. Blood gases can be valuable in the management of patients on ventilators or being weaned from ventilators. Blood gas values are used to determine acid-base status, the type of imbalance, and the degree of compensation as summarized in the following section. Restoration of pH to near-normal values is referred to as fully compensated balance. When pH values are moving in the same direction (i.e., increasing or decreasing) as the $p\text{CO}_2$ or HCO_3^- , the imbalance is metabolic. When the pH values are moving in the opposite direction from the $p\text{CO}_2$ or HCO_3^- , the imbalance is caused by respiratory disturbances. To remember this concept, the following mnemonic can be useful: MeTRO = **Metabolic Together, Respiratory Opposite**.

Acid-Base Disturbance	pH	$p\text{CO}_2$	$p\text{O}_2$	HCO_3^-
Respiratory Acidosis				
Uncompensated	Decreased	Increased	Normal	Normal
Compensated	Normal	Increased	Increased	Increased
Respiratory Alkalosis				
Uncompensated	Increased	Decreased	Normal	Normal
Compensated	Normal	Decreased	Decreased	Decreased
Metabolic (Nonrespiratory) Acidosis				
Uncompensated	Decreased	Normal	Decreased	Decreased
Compensated	Normal	Decreased	Decreased	Decreased
Metabolic (Nonrespiratory) Alkalosis				
Uncompensated	Increased	Normal	Increased	Increased
Compensated	Normal	Increased	Increased	Increased

RESULT:

- **Acid-base imbalance is determined by evaluating pH, $p\text{CO}_2$, and HCO_3^- values. pH less than 7.35 reflects an acidic state, whereas pH greater than 7.45 reflects alkalosis. $p\text{CO}_2$ and HCO_3^- determine**

whether the imbalance is respiratory or nonrespiratory (metabolic). Because a patient may have more than one imbalance and may also be in the process of compensating, the interpretation of blood gas values may not always seem straightforward.

- **Respiratory conditions that interfere with normal breathing will cause CO_2 to be retained in the blood. This results in an increase of circulating carbonic acid and a corresponding decrease in pH (respiratory acidosis). Acute respiratory acidosis can occur in acute pulmonary edema, severe respiratory infections, bronchial obstruction, pneumothorax, hemothorax, open chest wounds, opiate poisoning, respiratory depressant drug therapy, and inhalation of air with a high CO_2 content. Chronic respiratory acidosis can be seen in patients with asthma, pulmonary fibrosis, emphysema, bronchiectasis, and respiratory depressant drug therapy. Alternately, respiratory conditions that increase the breathing rate will cause CO_2 to be removed from the alveoli more rapidly than it is being produced. This will result in an alkaline pH. Acute respiratory alkalosis may be seen in anxiety, hysteria, hyperventilation, and pulmonary embolus and with an increase in artificial ventilation. Chronic respiratory alkalosis may be seen in high fever, administration of drugs (e.g., salicylate and sulfa) that stimulate the respiratory system, hepatic coma, hypoxia of high altitude, and central nervous system (CNS) lesions or injury that result in stimulation of the respiratory center.**
- **Metabolic (nonrespiratory) conditions that cause the excessive formation or decreased excretion of organic or inorganic acids result in metabolic acidosis. Some of these conditions include ingestion of salicylates, ethylene glycol, and methanol, as well as uncontrolled diabetes, starvation, shock, renal disease,**

and biliary or pancreatic fistula. Metabolic alkalosis results from conditions that increase pH, as can be seen in excessive intake of antacids to treat gastritis or peptic ulcer, excessive administration of HCO_3^- , loss of stomach acid caused by protracted vomiting, cystic fibrosis, or potassium and chloride deficiencies.

Respiratory Acidosis

- Decreased pH
- Decreased O_2 saturation
- Increased pCO_2 :
 - Acute intermittent porphyria
 - Anemia (severe)
 - Anorexia
 - Anoxia
 - Asthma
 - Atelectasis
 - Bronchitis
 - Bronchoconstriction
 - Carbon monoxide poisoning
 - Cardiac disorders
 - Congenital heart defects
 - Congestive heart failure
 - COPD
 - Cystic fibrosis
 - Depression of respiratory center
 - Drugs depressing the respiratory system
 - Electrolyte disturbances (severe)
 - Emphysema
 - Fever
 - Head injury
 - Hypercapnia
 - Hypothyroidism (severe)
 - Near drowning
 - Pleural effusion
 - Pneumonia
 - Pneumothorax
 - Poisoning
 - Poliomyelitis
 - Pulmonary edema
 - Pulmonary embolism
 - Pulmonary tuberculosis
 - Respiratory distress syndrome (adult and neonatal)
 - Respiratory failure
 - Sarcoidosis

Smoking
Tumor

- A decreased pO_2 that increases pCO_2 :

Decreased alveolar gas exchange:
cancer, compression or resection of lung, respiratory distress syndrome (newborns), sarcoidosis

Decreased ventilation or perfusion:
asthma, bronchiectasis, bronchitis, cancer, croup, cystic fibrosis (mucoviscidosis), emphysema, granulomata, pneumonia, pulmonary infarction, shock

Hypoxemia: anesthesia, carbon monoxide exposure, cardiac disorders, high altitudes, near drowning, presence of abnormal hemoglobins

Hypoventilation: cerebrovascular incident, drugs depressing the respiratory system, head injury

Right-to-left shunt: congenital heart disease, intrapulmonary venoarterial shunting

Compensation

- Increased pO_2 :
Hyperbaric oxygenation
Hyperventilation
- Increased base excess:
Increased HCO_3^- to bring pH to (near) normal

Respiratory Alkalosis

- Increased pH
- Decreased pCO_2 :
Anxiety
CNS lesions or injuries that cause stimulation of the respiratory center
Excessive artificial ventilation
Fever
Head injury
Hyperthermia
Hyperventilation
Hysteria
Salicylate intoxication

Compensation

- Decreased pO_2 :
Rebreather mask
- Decreased base excess:
Decreased HCO_3^- to bring pH to (near) normal

Metabolic Acidosis

- Decreased pH
- Decreased HCO_3^-
- Decreased base excess
- Decreased tCO_2 :
Decreased excretion of H^+ : acquired (e.g., drugs, hypercalcemia), Addison's disease, diabetic ketoacidosis, Fanconi's syndrome, inherited (e.g., cystinosis, Wilson's disease), renal failure, renal tubular acidosis
Increased acid intake
Increased formation of acids: diabetic ketoacidosis, high-fat/low-carbohydrate diets
Increased loss of alkaline body fluids: diarrhea, excess potassium, fistula
Renal disease

Compensation


- Decreased pCO_2 :
Hyperventilation

Metabolic Alkalosis

- Increased pH
- Increased HCO_3^-
- Increased base excess
- Increased tCO_2 :
Alkali ingestion (excessive)
Anoxia
Gastric suctioning
Hypochloremic states
Hypokalemic states
Potassium depletion: Cushing's disease, diarrhea, diuresis, excessive vomiting, excessive ingestion of licorice, inadequate potassium intake, potassium-losing nephropathy, steroid administration
Salicylate intoxication
Shock
Vomiting

Compensation

- Increased tCO_2 :
Hypoventilation

CRITICAL VALUES:  Note and immediately report to the health care practitioner (HCP) any critically increased or decreased values and related symptoms.

Arterial Blood Gas Parameter	Less Than	Greater Than
pH	7.20	7.60
HCO ₃ ⁻	10 mmol/L	40 mmol/L
pCO ₂	20 mm Hg	67 mm Hg
pO ₂	45 mm Hg	

INTERFERING FACTORS:

- Drugs that may cause an increase in HCO₃⁻ include acetylsalicylic acid (initially), antacids, carbenicillin, carbenoxolone, ethacrynic acid, glycyrrhiza (licorice), laxatives, mafenide, and sodium bicarbonate.
- Drugs that may cause a decrease in HCO₃⁻ include acetazolamide, acetylsalicylic acid (long term or high doses), citrates, dimethadione, ether, ethylene glycol, fluorides, mercury compounds (laxatives), methylenedioxyamphetamine, paraldehyde, and xylitol.
- Drugs that may cause an increase in pCO₂ include acetylsalicylic acid, aldosterone bicarbonate, carbenicillin, carbenoxolone, corticosteroids, dexamethasone, ethacrynic acid, laxatives (chronic abuse), and x-ray contrast agents.
- Drugs that may cause a decrease in pCO₂ include acetazolamide, acetylsalicylic acid, ethamivan, neuromuscular relaxants (secondary to postoperative hyperventilation), NSD 3004 (arterial long-acting carbonic anhydrase inhibitor), theophylline, tromethamine, and xylitol.
- Drugs that may cause an increase in pO₂ include theophylline and urokinase.
- Drugs that may cause a decrease in pO₂ include althesin, barbiturates, granulocyte-macrophage colony-stimulating factor, isoproterenol, and meperidine.
- Samples for blood gases are obtained by arterial puncture, which carries a risk of bleeding, especially in patients who have bleeding disorders or are taking medications for a bleeding disorder.
- Recent blood transfusion may produce misleading values.
- Specimens with extremely elevated white blood cell counts will undergo misleading decreases in pH resulting from cellular metabolism, if transport to the laboratory is delayed.
- Specimens collected soon after a change in inspired oxygen has occurred will not accurately reflect the patient's oxygenation status.
- Specimens collected within 20 to 30 min of respiratory passage suctioning or other respiratory therapy will not be accurate.
- Excessive differences in actual body temperature relative to normal body temperature will not be reflected in the results. Temperature affects the amount of gas in solution. Blood gas analyzers measure samples at 37°C (98.6°F); therefore, if the patient is hyperthermic or hypothermic, it is important to notify the laboratory of the patient's actual body temperature at the time the specimen was collected. Fever will increase actual pO₂ and pCO₂ values; therefore, the uncorrected values measured at 37°C will be falsely decreased. Hypothermia

decreases actual pO_2 and pCO_2 values; therefore, the uncorrected values measured at $37^\circ C$ will be falsely increased.

- A falsely increased O_2 saturation may occur because of elevated levels of carbon monoxide in the blood.
- O_2 saturation is a calculated parameter based on an assumption of 100% hemoglobin A. Values may be misleading when hemoglobin variants with different oxygen dissociation curves are present. Hemoglobin S will cause a shift to the right, indicating decreased oxygen binding. Fetal hemoglobin and methemoglobin will cause a shift to the left, indicating increased oxygen binding.
- Excessive amounts of heparin in the sample may falsely decrease pH, pCO_2 , and pO_2 .
- Citrates should never be used as an anticoagulant in evacuated collection tubes for venous blood gas determinations because citrates will cause a marked analytic decrease in pH.
- Air bubbles or blood clots in the specimen are cause for rejection. Air bubbles in the specimen can falsely elevate or decrease the results depending on the patient's blood gas status. If an evacuated tube is used for venous blood gas specimen collection, the tube must be removed from the needle before the needle is withdrawn from the arm or else the sample will be contaminated with room air.
- Specimens should be placed in ice slurry immediately after collection because blood cells continue to carry out metabolic processes in the specimen after it has been removed from the patient. These natural life processes can affect pH, pO_2 ,


pCO_2 , and the other calculated values in a short period of time. The cold temperature provided by the ice slurry will slow down, but not completely stop, metabolic changes occurring in the sample over time. Iced specimens not analyzed within 60 min of collection should be rejected for analysis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess acid-base balance and oxygenation level of the blood.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex and anesthetics.
- ▶ Obtain a history of the patient's respiratory system, any bleeding disorders or other symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Record the patient's temperature.
- ▶ Indicate the type of oxygen, mode of oxygen delivery, and delivery rate as part of the test requisition process. Wait 30 min after a change in type or mode of oxygen delivery or rate for specimen collection.

Review the procedure with the patient and advise rest for 30 min before specimen collection. Explain to the patient that an arterial puncture may be painful. The site may be anesthetized with 1% to 2% lidocaine before puncture. Inform the patient that specimen collection and postprocedure care of the puncture site usually take 10 to 15 min. The person collecting the specimen should be notified beforehand if the patient is receiving anticoagulant therapy, or taking aspirin or other natural products that may prolong bleeding from the puncture site.

 If the sample is to be collected by radial artery puncture, perform an Allen test before puncture to ensure that the patient has adequate collateral circulation to the hand if thrombosis of the radial artery occurs after arterial puncture. The modified Allen test is performed as follows: extend the patient's wrist over a rolled towel. Ask the patient to make a fist with the hand extended over the towel. Use the second and third fingers to locate the pulses of the ulnar and radial arteries on the palmar surface of the wrist. (The thumb should not be used to locate these arteries because it has a pulse.) Compress both arteries and ask the patient to open and close the fist several times until the palm turns pale. Release pressure on the ulnar artery only. Color should return to the palm within 5 sec if the ulnar artery is functioning. This is a positive Allen test, and blood gases may be drawn from the radial artery site. The Allen test should then be performed on the opposite hand. The hand to which color is restored fastest has better circulation and should be selected for specimen collection.

Sensitivity to social and cultural issues, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

There are no food, fluid, or medication restrictions unless by medical direction. Prepare an ice slurry in a cup or plastic bag to have ready for immedi-

ate transport of the specimen to the laboratory.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions and follow the general guidelines in Appendix A. Positively identify the patient and label the appropriate tubes with the corresponding patient demographics, date, and time of collection.

Arterial:

- ▶ Perform an arterial puncture and collect the specimen in an air-free heparinized syringe. There is no demonstrable difference in results between samples collected in plastic syringes and samples collected in glass syringes. It is very important that no room air be introduced into the collection container because the gases in the room and in the sample will begin equilibrating immediately. The end of the syringe must be stoppered immediately after the needle is withdrawn and removed. Apply a pressure dressing over the puncture site. Samples should be mixed by gentle rolling of the syringe to ensure proper mixing of the heparin with the sample, which will prevent the formation of small clots leading to rejection of the sample. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag. Promptly transport the specimen to the laboratory for processing and analysis.

Venous:

- ▶ Central venous blood is collected in a heparinized syringe.
- ▶ Venous blood is collected percutaneously by venipuncture in a 5-mL

green-top (heparin) tube (for adult patients) or a heparinized microtainer (for pediatric patients). The vacuum collection tube must be removed from the needle before the needle is removed from the patient's arm. Apply a pressure dressing over the puncture site. Samples should be mixed by gentle rolling of the syringe to ensure proper mixing of the heparin with the sample, which will prevent the formation of small clots leading to rejection of the sample. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen label can be protected from water in the ice slurry by first placing the specimen in a protective plastic bag. Promptly transport the specimen to the laboratory for processing and analysis.

Capillary:

Perform a capillary puncture and collect the specimen in two 250-microliter heparinized capillaries (scalp or heel for neonatal patients) or a heparinized microtainer (for pediatric patients). Observe standard precautions and follow the general guidelines in Appendix A. The capillary tubes should be filled as much as possible and capped on both ends. Some hospitals recommend that metal "fleas" be added to the capillary tube before the ends are capped. During transport, a magnet can be moved up and down the outside of the capillary tube to facilitate mixing and prevent the formation of clots, which would cause rejection of the sample. It is important to inform the laboratory or respiratory therapy staff of the number of fleas used so the fleas can be accounted for and removed before the sample is introduced into the blood gas analyzers. Fleas left in the sample may damage the blood gas equipment if allowed to enter the analyzer. Microtainer samples should be mixed by gentle rolling of the capillary tube to ensure proper mixing of the heparin with the sample, which will prevent the

formation of small clots leading to rejection of the sample. Promptly transport the specimen to the laboratory for processing and analysis.

Cord Blood:

The sample may be collected directly from the cord, using a syringe. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen label can be protected from water in the ice slurry by first placing the specimen in a protective plastic bag. Promptly transport the specimen to the laboratory for processing and analysis.

Scalp Sample:

Samples for scalp pH may be collected anaerobically before delivery in special scalp-sample collection capillaries and transported immediately to the laboratory for analysis. Some hospitals recommend that fleas be added to the scalp tube before the ends are capped. See preceding section on capillary collection for discussion of fleas.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Pressure should be applied to the puncture site for at least 5 min in the unanticoagulated patient and for at least 15 min in the case of a patient receiving anticoagulant therapy. Observe puncture site for bleeding or hematoma formation. Apply pressure bandage.
- ▶ Observe the patient for signs or symptoms of respiratory acidosis, such as dyspnea, headache, tachycardia, pallor, diaphoresis, apprehension, drowsiness, coma, hypertension, or disorientation.
- ▶ Teach the patient breathing exercises to assist with the appropriate exchange of oxygen and carbon dioxide.
- ▶ Administer oxygen, if appropriate.

- ◆ Teach the patient how to properly use the incentive spirometer device or mininebulizer, if ordered.
- ◆ Observe the patient for signs or symptoms of respiratory alkalosis, such as tachypnea, restlessness, agitation, tetany, numbness, seizures, muscle cramps, dizziness, or tingling fingertips.
- ◆ Instruct the patient to breathe deeply and slowly; performing this type of breathing exercise into a paper bag decreases hyperventilation and quickly helps the patient's breathing return to normal.
- ◆ Observe the patient for signs or symptoms of metabolic acidosis, such as rapid breathing, flushed skin, nausea, vomiting, dysrhythmias, coma, hypotension, hyperventilation, and restlessness.
- ◆ Observe the patient for signs or symptoms of metabolic alkalosis, such as shallow breathing, weakness, dysrhythmias, tetany, hypokalemia, hyperactive reflexes, and excessive vomiting.
- ◆ **Nutritional considerations:** Abnormal blood gas values may be associated with diseases of the respiratory system. Malnutrition is commonly seen in patients with severe respiratory disease for reasons including fatigue, lack of appetite, and gastrointestinal distress. Research has estimated that the daily caloric intake required for respiration of patients with COPD is 10 times higher than that of normal individuals. Inadequate nutrition can result in hypophosphatemia, especially in the respirator-dependent patient. During periods of starvation, phosphorus leaves the intracellular space and moves outside the tissue, resulting in dangerously decreased phosphorus levels.

- ◆ Adequate intake of vitamins A and C is also important to prevent pulmonary infection and to decrease the extent of lung tissue damage. The importance of following the prescribed diet should be stressed to the patient and/or caregiver.
- ◆ Water balance needs to be closely monitored in COPD patients. Fluid retention can lead to pulmonary edema.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include α_1 -AT, anion gap, arterial/alveolar oxygen ratio, biopsy lung, bronchoscopy, carboxy-hemoglobin, chest x-ray, chloride sweat, complete blood count hemoglobin, complete blood count WBC and diff, culture and smear for mycobacteria, culture bacterial sputum, culture viral, cytology sputum, electrolytes, Gram stain, IgE, lactic acid, lung perfusion scan, lung ventilation scan, osmolality, phosphorus, plethysmography, pleural fluid analysis, pulse oximetry, PFT, and TB skin tests.
- ◆ Refer to the Cardiovascular, Genitourinary, and Respiratory System tables at the back of the book for related tests by body system.

Blood Groups and Antibodies

B

SYNONYM/ACRONYM: ABO group and Rh typing, blood group antibodies, type and screen, type and crossmatch.

SPECIMEN: Serum (2 mL) collected in a red-top tube or whole blood (2 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: FDA-licensed reagents with glass slides, glass tubes, gel, or automated systems) Compatibility (no clumping or hemolysis).

Blood Type	Rh Type (with any ABO)	Other Antibodies That React at 37°C or with Antiglobulin	Other Antibodies That React at Room Temperature or Below
A	Positive	Kell	Lewis
B	Negative	Duffy	P
AB		Kidd	MN
O		S s U	Cold agglutinins

DESCRIPTION: Blood typing is a series of tests that include the ABO and Rh blood-group system performed to detect surface antigens on red blood cells by an agglutination test and compatibility tests to determine antibodies against these antigens. The major antigens in the ABO system are A and B, although AB and O are also common phenotypes. The patient with A antigens has group A blood; the patient with B antigens has group B blood. The patient with both A and B antigens has group AB blood (universal recipient); the patient with neither A nor B antigens has group O blood (universal donor). Blood group and type is genetically determined. After 6 mo of age, individuals develop serum antibodies that react with

A or B antigen absent from their own red blood cells. These are called *anti-A* and *anti-B* antibodies.

In ABO blood typing, the patient's red blood cells mix with anti-A and anti-B sera, a process known as *forward grouping*. The process then reverses, and the patient's serum mixes with type A and B cells in *reverse grouping*.

Generally, only blood with the same ABO group and Rh type as the recipient is transfused because the anti-A and anti-B antibodies are strong agglutinins that cause a rapid, complement-mediated destruction of incompatible cells. However, blood donations have decreased nationwide creating shortages in the available supply. Safe substitutions with blood of a different

group and/or Rh type may occur based on the inventory of available units. Many laboratories require consultation with the requesting health care provider (HCP) prior to issuing Rh-positive units to an Rh-negative individual.

ABO and Rh testing is also performed as a prenatal screen in pregnant women to identify the risk of hemolytic disease of the newborn. Although most of the anti-A and anti-B activity resides in the immunoglobulin M (IgM) class of immunoglobulins, some activity rests with immunoglobulin G (IgG). Anti-A and anti-B antibodies of the IgG class coat the red blood cells without immediately affecting their viability and can readily cross the placenta, resulting in hemolytic disease of the newborn. Individuals with type O blood frequently have more IgG anti-A and anti-B than other people; thus, ABO hemolytic disease of the newborn will affect infants of type O mothers almost exclusively (unless the newborn is also type O).

Major antigens of the Rh system are D (or Rh₀), C, E, c, and e. Individuals whose red blood cells possess D antigen are called Rh-positive; those who lack D antigen are called Rh-negative, no matter what other Rh antigens are present. Individuals who are Rh-negative produce anti-D antibodies when exposed to Rh-positive cells by either transfusions or pregnancy. These anti-D antibodies cross the placenta to the fetus and can cause hemolytic disease of the newborn or transfusion reactions if Rh-positive blood is administered.

INDICATIONS:

- Determine ABO and Rh compatibility of donor and recipient before transfusion (Type and Screen or Crossmatch).
- Determine anti-D antibody titer of Rh-negative mothers after sensitization by pregnancy with an Rh-positive fetus.
- Determine the need for a microdose of immunosuppressive therapy (e.g., with RhoGAM) during the first 12 wk of gestation or a standard dose after 12 weeks' gestation for complications such as abortion, miscarriage, vaginal hemorrhage, ectopic pregnancy, or abdominal trauma.
- Determine Rh blood type and perform antibody screen of prenatal patients on initial visit to determine maternal Rh type and to indicate whether maternal red blood cells have been sensitized by any antibodies known to cause hemolytic disease of the newborn, especially anti-D antibody. Rh blood type, antibody screen, and antibody titration (if an antibody has been indentified) will be rechecked at 28 weeks' gestation and prior to injection of prophylactic standard dose of Rh₀(D) immune globulin Rhogam IM or Rhophylac IM or IV for Rh-negative mothers. These tests will also be repeated after delivery of an Rh-positive fetus to an Rh-negative mother and prior to injection of prophylactic standard dose of Rh₀(D) immune globulin (if maternal Rh-negative blood has not been previously sensitized with Rh-positive cells resulting in a positive anti-D antibody titer). A postpartum blood sample must be evaluated for fetal-maternal bleed on all Rh-negative mothers to determine the need for additional doses of Rh immune globulin. One

in 300 cases will demonstrate hemorrhage greater than 15 mL of blood and require additional Rh₀(D) immune globulin.

- Identify donor ABO and Rh blood type for stored blood.
- Identify maternal and infant ABO and Rh blood types to predict risk of hemolytic disease of the newborn.
- Identify the patient's ABO and Rh blood type, especially before a procedure in which blood loss is a

threat or blood replacement may be needed.

RESULT:

- ABO system: A, B, AB, or O specific to person
- Rh system: positive or negative specific to person
- Crossmatching: compatibility between donor and recipient
- Incompatibility indicated by clumping (agglutination) of red blood cells

Group and Type	Incidence (%)	Alternative Transfusion Group and Type of PACKED CELL UNITS in Order of Preference If Patient's Own Group and Type Not Available
O Positive	37.4	O Negative
O Negative	6.6	O Positive*
A Positive	35.7	A Negative, O Positive, O Negative
A Negative	6.3	O Negative, A Positive,* O Positive*
B Positive	8.5	B Negative, O Positive, O Negative
B Negative	1.5	O Negative, B Positive,* O Positive*
AB Positive	3.4	AB Negative, A Positive, B Positive, A Negative, B Negative, O Positive, O Negative
AB Negative	0.6	A Negative, B Negative, O Negative, AB Positive,* A Positive,* B Positive,* O Positive*
Rh Type		
Rh Positive	85–90	
Rh Negative	10–15	

*If blood units of exact match to the patient's group and type are not available, a switch in ABO blood group is preferable to a change in Rh type. However, in extreme circumstances, Rh-positive blood can be issued to an Rh-negative recipient. It is very likely that the recipient will develop antibodies as the result of receiving Rh-positive red blood cells. Rh antibodies are highly immunogenic, and, once developed, the recipient can only receive Rh-negative blood for subsequent red blood cell transfusion.

CRITICAL VALUES: 

Note and immediately report to the HCP any signs and symptoms associated with a blood transfusion reaction.

Signs and symptoms of blood transfusion reaction range from mildly febrile to anaphylactic and may include chills, dyspnea, fever,

headache, nausea, vomiting, palpitations and tachycardia, chest or back pain, apprehension, flushing, hives, angioedema, diarrhea, hypotension, oliguria, hemoglobinuria, renal failure, sepsis, shock, and jaundice. Complications from disseminated intravascular coagulation (DIC) may also occur.

Possible interventions in mildly febrile reactions would include slowing the rate of infusion, then verifying and comparing patient identification, transfusion requisition, and blood bag label. The patient should be monitored closely for further development of signs and symptoms. Administration of epinephrine may be ordered.

Possible interventions in a more severe transfusion reaction may include immediate cessation of infusion, notification of the HCP, keeping the IV line open with saline or lactated Ringer's solution, collection of red- and lavender-top tubes for post-transfusion work-up, collection of urine, monitoring vital signs every 5 min, ordering additional testing if DIC is suspected, maintaining patent airway and blood pressure, and administering mannitol. See Appendix D for a more detailed description of transfusion reactions and potential nursing interventions.

INTERFERING FACTORS:

- Drugs including levodopa, methyldopa, methyldopate hydrochloride, and cephalexin may cause a false positive result in Rh typing and in antibody screens.
- Recent administration of blood, blood products, dextran, or IV contrast medium causes cellular aggregation resembling agglutination in ABO typing.
- Contrast material such as iodine, barium, and gadolinium may interfere with testing.
- Abnormal proteins, cold agglutinins, and bacteremia may interfere with testing.
- Testing does not detect every antibody and may miss the presence of a weak antibody.
- History of bone marrow transplant, cancer, or leukemia may cause discrepancy in ABO typing.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to determine ABO blood group and Rh type.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's immune and hematopoietic systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Note any recent or past procedures, especially blood or blood product transfusion or bone marrow transplantation, that could complicate or interfere with test results.
- ◆ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions unless by medical direction.
- ◆ *Make sure a written and informed consent has been signed prior to any transfusion of ABO- and Rh-compatible blood products.*

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate

tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- ▶ Although correct patient identification is important for test specimens, it is crucial when blood is collected for type and crossmatch. Therefore, additional requirements are necessary, including the verification of two unique identifiers that could include any two unique patient demographics such as name, date of birth, social security number, hospital number, date, or blood bank number on requisition and specimen labels; completing and applying a wristband on the arm with the same information; and placing labels with the same information and blood bank number on blood sample tubes.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Inform patient of ABO blood and Rh type, and advise the patient to record

the information on a card or other document normally carried.

- ▶ Inform women who are Rh-negative to inform the HCP of their Rh-negative status if they become pregnant or need a transfusion.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include Coomb's antiglobulin, bilirubin, complete blood count, complete blood count hematocrit, complete blood count hemoglobin, complete blood count platelet count, complete blood count RBC count, cold agglutinin, FDP, fecal analysis, GI blood loss scan, haptoglobin, Ig A, iron, Kleihauer-Betke, laparoscopy abdominal, Meckel's diverticulum scan, and UA.
- ▶ Refer to the Immune and Hematopoietic System tables at the back of the book for related tests by body system.

Blood Pool Imaging

SYNONYM/ACRONYM: Cardiac blood pool scan, ejection fraction study, gated cardiac scan, radionuclide ventriculogram, wall motion study, MUGA.

AREA OF APPLICATION: Heart.

CONTRAST: Intravenous radioactive material.

DESCRIPTION: Multigated blood pool imaging (MUGA; also known as *cardiac blood pool scan*) is used to diagnose cardiac abnormalities involving the left ventricle and myocardial wall abnormalities by imaging the blood within the cardiac chamber rather than the myocardium. The ventricular blood pool can be imaged during the initial transit of a peripherally injected, intravenous bolus of radionuclide (first-pass technique) or when the radionuclide has reached equilibrium concentration. The patient's electrocardiogram (ECG) is synchronized to the gamma camera imager and computer and thereby termed "gated." For multigated studies, technetium-99m (Tc-99m) pertechnetate is injected after an injection of pyrophosphate, allowing the labeling of circulating red blood cells; Tc-99m sulfur colloid is used for first-pass studies. Studies detect abnormalities in heart wall motion at rest or with exercise, ejection fraction, ventricular dilation, stroke volume, and cardiac output. The MUGA procedure, performed with the heart in motion, is used to obtain multiple images of the heart in contraction and relaxation during an R-to-R cardiac cycle. The resulting images can be displayed in a cinematic mode to visualize cardiac function. Repetitive data acquisitions are possible during graded levels of exercise, usually a bicycle ergometer or handgrip, to assess ventricular functional response to exercise.

After the administration of sublingual nitroglycerin, the MUGA scan can evaluate the effectiveness of the drug on ventricular function.

Heart shunt imaging is done in conjunction with a resting MUGA scan to obtain ejection fraction and assess regional wall motion.

First-pass cardiac flow study is done to study heart chamber disorders, including left-to-right and right-to-left shunts, determine both right and left ventricular ejection fractions, and assess blood flow through the great vessels. The study uses a jugular or antecubital vein injection of the radionuclide.

INDICATIONS:

- Aid in the diagnosis of myocardial infarction
- Aid in the diagnosis of true or false ventricular aneurysms
- Aid in the diagnosis of valvular heart disease and determining the optimal time for valve replacement surgery
- Detect left-to-right shunts and determine pulmonary-to-systemic blood flow ratios, especially in children
- Determine cardiomyopathy
- Determine drug cardiotoxicity to stop therapy before development of congestive heart failure
- Determine ischemic coronary artery disease
- Differentiate between chronic obstructive pulmonary disease and left ventricular failure
- Evaluate ventricular size, function, and wall motion after an acute episode or in chronic heart disease
- Quantitate cardiac output by calculating global or regional ejection fraction

RESULT:

Normal findings in:

- Normal wall motion, ejection fraction (55% to 65%), coronary blood flow, ventricular size and function, and symmetry in contractions of the left ventricle

Abnormal findings in:

- Abnormal wall motion (akinesia or dyskinesia)
- Cardiac hypertrophy
- Cardiac ischemia
- Enlarged left ventricle
- Infarcted areas are akinetic
- Ischemic areas are hypokinetic
- Myocardial infarction

CRITICAL VALUES:

- Myocardial infarction

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Dipyridamole testing is not performed in patients with anginal pain at rest or in patients with severe atherosclerotic coronary vessels.
- Chemical stress with vasodilators should not be done to patients having asthma; bronchospasm can occur.

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and can produce unclear images

Other considerations:

- Conditions such as chest wall trauma, cardiac trauma, angina that is difficult to control, significant cardiac arrhythmias, or a recent cardioversion procedure may affect test results.

- Atrial fibrillation and extrasystoles invalidate the procedure.
- Suboptimal cardiac stress or patient exhaustion, preventing maximum heart rate testing, will affect results when the procedure is done in conjunction with exercise testing.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the pumping action of the heart.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals (see Appendix F).
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department, by a HCP specializing in this procedure and takes approximately 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to wear walking shoes for the treadmill or bicycle exercise. Emphasize to the patient the importance of reporting fatigue, pain, or shortness of breathe.
- ▶ Instruct the patient to remove external metallic objects from the area to be examined prior to the procedure.
- ▶ The patient should fast and restrict fluids for 4 hr prior to the procedure. Instruct the patient to withhold medications for 24 hr before the test as ordered by the HCP. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ The patient is placed at rest in the supine position on the scanning table.
- ▶ Expose the chest and attach the ECG leads. Record baseline readings.
- ▶ IV radionuclide is administered and the heart is scanned with images taken in various positions over the entire cardiac cycle.
- ▶ When the scan is to be done under exercise conditions, the patient is assisted onto the treadmill or bicycle ergometer and is exercised to a calculated 80% to 85% of the maximum heart rate as determined by the protocol selected. Images are done at each exercise level and begun immediately after injection of the radionuclide.
- ▶ If nitroglycerin is given, a HCP assessing the baseline MUGA scan injects the medication. Additional scans are repeated until blood pressure reaches the desired level.
- ▶ Patients who cannot exercise are given dipyridamole before the radionuclide is injected.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions.
- ▶ Ensure that the patient has removed external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the

radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.

- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Evaluate the patient's vital signs. Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by HCP. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Instruct the patient to resume usual dietary, medication, and activity, as directed by the HCP.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Monitor ECG tracings and compare with baseline readings until stable.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing

gloves. Then wash hands after the gloves are removed.

- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate and determine the need for a change in therapy or progression of the disease process. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, ANP, blood gases, BNP, calcium, ionized calcium, cholesterol (total, HDL, and LDL), CRP, CT cardiac scoring, CK and isoenzymes, culture viral, echocardiography, echocardiography transesophageal, ECG, exercise stress test, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI chest, MI infarct scan, myocardial perfusion heart scan, myoglobin, pericardial fluid analysis, PET heart scan, potassium, triglycerides, and troponin.
- ▶ Refer to the Cardiovascular System table at the back of the book for related tests by body system.

Bone Mineral Densitometry

B

SYNONYM/ACRONYM: Ultrasound densitometry, DEXA, DXA, SXA, QCT, RA.

Dual-energy x-ray absorptiometry (DEXA, DXA): Two x-rays of different energy levels measure bone mineral density and predict risk of fracture.

Single-energy x-ray absorptiometry (SXA): A single-energy x-ray measures bone density at peripheral sites.

Quantitative computed tomography (QCT): QCT is used to examine the lumbar vertebrae. It measures trabecular and cortical bone density. Results are compared to a known standard. This test is the most expensive and involves the highest radiation dose of all techniques.

Radiographic absorptiometry (RA): A standard x-ray of the hand. Results are compared to a known standard.

Ultrasound densitometry: Studies bone mineral content in peripheral densitometry sites such as the heel or wrist. It is not as precise as x-ray techniques, but less expensive than other techniques.

AREA OF APPLICATION: Lumbar spine, heel, hip, wrist, whole body.

CONTRAST: None.

DESCRIPTION: Bone mineral density (BMD) can be measured at any of several body sites, including the spine, hip, wrist, and heel. Machines to measure BMD include computed tomography (CT), radiographic absorptiometry, ultrasound, single-energy x-ray absorptiometry (SXA), and most commonly, dual-energy x-ray absorptiometry (DEXA). The radiation exposure from SXA and DEXA machines is approximately one-tenth that of a standard chest x-ray.

The BMD values measured by the various techniques cannot be directly compared. Therefore, they are stated in terms of standard deviation (SD) units. The patient's T-score is the number of SD units above or below the average BMD in young adults. A Z-score is the number of SD

units above or below the average value for a person of the same age as the measured patient. For most BMD readings, 1 SD is equivalent to 10% to 12% of the average young-normal BMD value. A T-score of -2.5 is therefore equivalent to a bone mineral loss of 30% when compared to a young adult.

INDICATIONS:

Osteoporosis is a condition characterized by low BMD, which results in increased risk of fracture. The National Osteoporosis Foundation estimates that 4 to 6 million postmenopausal women in the United States have osteoporosis, and an additional 13 to 17 million (30% to 50%) have low bone density at the hip. It is estimated that one of every two women will experience a

fracture as a result of low bone mineral content in her lifetime. The measurement of BMD gives the best indication of risk for a fracture. The lower the BMD, the greater the risk of fracture. The most common fractures are those of the hip, vertebrae, and distal forearm. Bone mineral loss is a disease of the entire skeleton and not restricted to the areas listed. The effect of the fractures has a wide range, from complete recovery to chronic pain, disability, and possible death.

- Determine the mineral content of bone
- Determine a possible cause of amenorrhea
- Establish a diagnosis of osteoporosis
- Evaluate bone demineralization associated with chronic renal failure
- Evaluate bone demineralization associated with immobilization
- Monitor changes in BMD due to medical problems or therapeutic intervention
- Predict future fracture risk

RESULT:

- T-score estimates the actual fracture risk compared to young adults.
- Normal bone mass is designated as a T-score value not less than -1 .
- Osteoporosis is defined as a BMD T-score value less than -2.5 .
- Low bone mass or osteopenia has T-scores from -1 to -2.5 .
- Fracture risk increases as BMD declines from young-normal levels (low T-scores).
- Low Z-scores in older adults can be misleading because low BMD is very common.
- Z-scores estimate fracture risk compared to others of the same age (versus young-normal adults).

CRITICAL VALUES: N/A

INTERFERING FACTORS OR FACTORS ASSOCIATED WITH INCREASED RISK OF OSTEOPOROSIS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects within the examination field (e.g., jewelry, earrings, and/or dental amalgams), which may inhibit organ visualization and can produce unclear images

Other considerations:

- The use of anticonvulsant drugs, cytotoxic drugs, tamoxifen, glucocorticoid, lithium, or heparin, as well as increased alcohol intake, increased aluminum levels, excessive thyroxin, renal dialysis, or smoking, may affect the test results by either increasing or decreasing the bone mineral content.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of exposure to radiation.

Other considerations as a result of altered BMD, not the BMD testing process:

- Vertebral fractures may cause complications including back pain, height loss, and kyphosis.
- Limited activity may result, including difficulty bending and reaching.
- Patient may have poor self-esteem resulting from the cosmetic effects of kyphosis.
- Potential restricted lung function may result from fractures.
- Fractures may alter abdominal anatomy, resulting in constipation, pain, distention, and diminished appetite.
- Potential for a restricted lifestyle may result in depression and other psychological symptoms.
- Possible increased dependency on family for basic care may occur.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses bone density.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's musculoskeletal system, symptoms and results of previously performed laboratory tests, and diagnostic and surgical procedures
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, or there may be moments of discomfort. Inform the patient that the procedure is usually performed in a radiology department by a HCP specializing in this procedure and support staff and takes approximately 60 min.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided. Patient's clothing may not need to be removed unless it contains metal that would interfere with the test.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in a supine position on a flat table with foam wedges, which help maintain position and immobilization.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of perceived

loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's

symptoms, previous BMD values, and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALP, antibodies anticyclic citrullinated peptide, ANA, arthrogram, arthroscopy, biopsy bone, bone scan, calcium, CRP, collagen cross-linked telopeptides, CT pelvis, CT spine, ESR, MRI musculoskeletal, MRI pelvis, osteocalcin, PTH, phosphorus, radiography bone, RF, synovial fluid analysis, and vitamin D.
- ▶ Refer to the Musculoskeletal System table in the back of the book for related tests by body system.

Bone Scan

SYNONYM/ACRONYM: Bone imaging, radionuclide bone scan, bone scintigraphy, whole-body bone scan.

AREA OF APPLICATION: Bone/skeleton.

CONTRAST: Intravenous radioactive material (diphosphonate compounds), usually combined with technetium-99m.

DESCRIPTION: This nuclear medicine scan assists in diagnosing and determining the extent of primary and metastatic bone disease and bone trauma, and monitors the progression of degenerative disorders. Abnormalities are identified by scanning 1 to 3 hr after the intravenous injection of a radionuclide such as technetium-99m methylene diphosphonate. Areas of increased uptake and activity on the bone scan represent abnormalities unless they occur

in normal areas of increased activity, such as the sternum, sacroiliac, clavicle, and scapular joints in adults, and growth centers and cranial sutures in children. The radionuclide mimics calcium physiologically and therefore localizes in bone with an intensity proportional to the degree of metabolic activity. Gallium, magnetic resonance imaging (MRI), or white blood cell scanning can follow a bone scan to obtain a more sensitive study if acute inflammatory

conditions such as osteomyelitis or septic arthritis are suspected. In addition, bone scan can detect fractures in patients who continue to have pain, even though x-rays have proved negative. A gamma camera detects the radiation emitted from the injected radioactive material. Whole-body or representative images of the skeletal system can be obtained.

INDICATIONS:

- Aid in the diagnosis of benign tumors or cysts
- Aid in the diagnosis of metabolic bone diseases
- Aid in the diagnosis of osteomyelitis
- Aid in the diagnosis of primary malignant bone tumors (e.g., osteogenic sarcoma, chondrosarcoma, Ewing's sarcoma, metastatic malignant tumors)
- Aid in the detection of traumatic or stress fractures
- Assess degenerative joint changes or acute septic arthritis
- Assess suspected child abuse
- Confirm temporomandibular joint derangement
- Detect Legg-Calvé-Perthes disease
- Determine the cause of unexplained bone or joint pain
- Evaluate the healing process following fracture, especially if an underlying bone disease is present
- Evaluate prosthetic joints for infection, loosening, dislocation, or breakage
- Evaluate tumor response to radiation or chemotherapy
- Identify appropriate site for bone biopsy, lesion excision, or debridement

RESULT:

Normal findings in:

- No abnormalities, as indicated by homogeneous and symmetric

distribution of the radionuclide throughout all skeletal structures

Abnormal findings in:

- Bone necrosis
- Degenerative arthritis
- Fracture
- Legg-Calvé-Perthes disease
- Metastatic bone neoplasm
- Osteomyelitis
- Paget's disease
- Primary metastatic bone tumors
- Renal osteodystrophy
- Rheumatoid arthritis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status.
- Metallic objects within the examination field (e.g., jewelry, earrings, and/or dental amalgams), which may inhibit organ visualization and can produce unclear images.
- Retained barium from a previous radiological procedure may affect the image.
- A distended bladder may obscure pelvic detail.
- Other nuclear scans done within the previous 24 to 48 hr may alter image.

Other considerations:

- The existence of multiple myeloma or thyroid cancer can result in a false-negative scan for bone abnormalities.
- Improper injection of the radionuclide may allow the tracer to

seep deep into the muscle tissue, producing erroneous hot spots.

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses bone disease before it can be detected with plain x-ray images.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of results of the patient's musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in a nuclear medicine department by a HCP specializing in this procedure, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ Instruct the patient to remove jewelry and other metallic objects in the area to be examined.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.

- ▶ Administer sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in a supine position on a flat table with foam wedges to help maintain position and immobilization.
- ▶ IV radionuclide is administered and images are taken immediately to assess blood flow to the bones.
- ▶ After a delay of 2 to 3 hr to allow the radionuclide to be taken up by the bones, multiple images are obtained over the complete skeleton. Delayed views may be taken up to 24 hr after the injection.
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.
- ▶ The patient may be imaged by single-photon emission computed tomography (SPECT) techniques to further clarify areas of suspicious radionuclide localization.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Instruct the patient to resume medication and activity as directed by the HCP.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site and to observe for bleeding, hematoma formation, and inflammation.
- ▶ If a woman who is breastfeeding must have a nuclear scan; she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She

- should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash ungloved hands after the gloves are removed.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies, anticyclic citrullinated peptide, ANA, arthroscopy, BMD, calcium, CRP, collagen cross-linked telopeptide, CT pelvis, CT spine, culture blood, ESR, MRI musculoskeletal, MRI pelvis, osteocalcin, radiography bone, synovial fluid analysis, RF, and white blood cell scan.
- ▶ Refer to the Musculoskeletal System table at the back of the book for related tests by body system.

Bronchoscopy

SYNONYM/ACRONYM: Flexible bronchoscopy.

AREA OF APPLICATION: Bronchial tree, larynx, trachea.

CONTRAST: None.

DESCRIPTION: This procedure provides direct visualization of the larynx, trachea, and bronchial tree by means of either a rigid or a flexible bronchoscope. A fiber-optic bronchoscope with a light incorporated is guided into the tracheobronchial tree. A local anesthetic may be used to allow the scope to be inserted through the mouth or nose into the trachea and into the bronchi. The patient must breathe during insertion and with the scope in place. The purpose of the procedure is both diagnostic and therapeutic.

The rigid bronchoscope allows visualization of the larger airways, including the lobar, segmental, and subsegmental bronchi, while maintaining effective gas exchange. Rigid bronchoscopy is preferred when large volumes of blood or secretions need to be aspirated, foreign bodies are to be removed, large-sized biopsy specimens are to be obtained, and for most bronchoscopies in children.

The flexible fiber-optic bronchoscope has a smaller lumen that is designed to allow for visualization of all segments of the bronchial tree. The accessory lumen of the bronchoscope is used for tissue biopsy, bronchial washings, instillation of anesthetic agents and medications, and to

obtain specimens with brushes for cytologic examination. In general, fiber-optic bronchoscopy is less traumatic to the surrounding tissues than the larger rigid bronchoscopes. Fiber-optic bronchoscopy is performed under local anesthesia; patient tolerance is better for fiber-optic bronchoscopy than for rigid bronchoscopy.

INDICATIONS:

- Detect end-stage bronchogenic cancer
- Detect lung infections and inflammation
- Determine etiology of persistent cough, hemoptysis, hoarseness, unexplained chest x-ray abnormalities, and/or abnormal cytologic findings in sputum
- Determine extent of smoke-inhalation or other traumatic injury
- Evaluate airway patency; aspirate deep or retained secretions
- Evaluate endotracheal tube placement or possible adverse sequelae to tube placement
- Evaluate possible airway obstruction in patients with known or suspected sleep apnea
- Evaluate respiratory distress and tachypnea in an infant to rule out tracheoesophageal fistula or other congenital anomaly

- Identify bleeding sites and remove clots within the tracheobronchial tree
- Identify hemorrhagic and inflammatory changes in Kaposi's sarcoma
- Intubate patients with cervical spine injuries or massive upper airway edema
- Remove foreign body
- Treat lung cancer through instillation of chemotherapeutic agents, implantation of radioisotopes, or laser palliative therapy
- Patients with disorders that limit extension of the neck
- Patients with severe obstructive tracheal conditions
- Patients with or having the potential for respiratory failure; introduction of the bronchoscope alone may cause a 10 to 20 mm Hg drop in PaO₂

RESULT:**Normal findings in:**

- Normal larynx, trachea, bronchi, bronchioles, and alveoli

Abnormal findings in:

- Abscess
- Bronchial diverticulum
- Bronchial stenosis
- Bronchogenic cancer
- Coccidioidomycosis, histoplasmosis, blastomycosis, phycosporidiosis
- Foreign bodies
- Inflammation
- Interstitial pulmonary disease
- Opportunistic lung infections (e.g., pneumocystitis, nocardia, cytomegalovirus)
- Strictures
- Tuberculosis
- Tumors

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

- Patients with bleeding disorders, especially those associated with uremia and cytotoxic chemotherapy
- Patients with pulmonary hypertension
- Patients with cardiac conditions or dysrhythmias

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects within the examination field (e.g., jewelry, earrings, and/or dental amalgams), which may inhibit organ visualization and can produce unclear images

Other considerations:

- Hypoxemic or hypercapnic states require continuous oxygen administration.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient the procedure assesses the lungs and respiratory system.
- ▶ Obtain a history of the patient's complaints or symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, and anesthetics.
- ▶ Obtain a history of the patient's immune and respiratory systems,

symptoms and results of previously performed laboratory tests, and diagnostic and surgical procedures.

- ▶ Note any recent procedures that can interfere with test results. Ensure that this procedure is performed before an upper gastrointestinal study or barium swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Instruct that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Explain that a sedative and/or analgesia may be administered to promote relaxation and reduce discomfort prior to the bronchoscopy. Atropine is usually given before bronchoscopy examinations to reduce bronchial secretions and prevent vagally induced bradycardia. Meperidine (Demerol) or morphine may be given as a sedative. Lidocaine is sprayed in the patient's throat to reduce discomfort caused by the presence of the tube. Inform the patient that the procedure is performed in a GI lab or radiology department, under sterile conditions, by a health care provider (HCP) specializing in this procedure. The procedure usually takes about 30 to 60 min to complete.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, antibiotics, anesthetics, and analgesics.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with food, fluid, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure that the patient has removed dentures, jewelry, and external metallic objects in the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and change into the gown, robe, and foot coverings provided.
- ▶ Avoid using morphine sulfate in those with asthma or other pulmonary disease. This drug can further exacerbate bronchospasms and respiratory impairment.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location, especially left or right lung.
- ▶ Assist the patient to a comfortable position, and direct the patient to breathe normally during the beginning of the general anesthesia. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.

- Record baseline vital signs and continue to monitor throughout the procedure. Protocols may vary from facility to facility.

Rigid Bronchoscopy:

- The patient is placed in the supine position and a general anesthetic is administered. The patient's neck is hyperextended, and the lightly lubricated bronchoscope is inserted orally and passed through the glottis. The patient's head is turned or repositioned to aid visualization of various segments.
- After inspection, the bronchial brush, suction catheter, biopsy forceps, laser, and electrocautery devices are introduced to obtain specimens for cytologic or microbiologic study or for therapeutic procedures.
- If a bronchial washing is performed, small amounts of solution are instilled into the airways and removed.
- After the procedure, the bronchoscope is removed and the patient is placed in a side-lying position with the head slightly elevated to promote recovery.

Fiberoptic Bronchoscopy:

- Provide mouth care to reduce oral bacterial flora.
- The patient is placed in a sitting position while the tongue and oropharynx are sprayed or swabbed with local anesthetic. Provide an emesis basin for the increased saliva and encourage the patient to spit out the saliva because the gag reflex may be impaired. When loss of sensation is adequate, the patient is placed in a supine or side-lying position. The fiberoptic scope can be introduced through the nose, the mouth, an endotracheal tube, a tracheostomy tube, or a rigid bronchoscope. Most common insertion is through the nose. Patients with copious secretions or massive hemoptysis, or in whom airway complications are more likely, may be intubated before the bronchoscopy. Additional local anesthetic is applied through the scope as it approaches the vocal cords and the carina, eliminating reflexes in these sensitive

areas. The fiberoptic approach allows visualization of airway segments without having to move the patient's head through various positions.

- After visual inspection of the lungs, tissue samples are collected from suspicious sites by bronchial brush or biopsy forceps to be used for cytologic and microbiologic studies.
- After the procedure, the bronchoscope is removed. Patients who had local anesthesia are placed in a semi-Fowler's position to recover.

General:

- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- Place tissue samples in properly labeled specimen containers containing formalin solution, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- Inform the patient that he or she may experience some throat soreness and hoarseness. Instruct patient to treat throat discomfort with lozenges and warm gargles when the gag reflex returns.
- Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature changes. Protocols may vary from facility to facility.
- Emergency resuscitation equipment should be readily available if the vocal cords become spastic after intubation.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia,

- hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ Observe the patient for hemoptysis, difficulty breathing, cough, air hunger, excessive coughing, pain, or absent breathing sounds over the affected area. Report to HCP.
 - ◆ Evaluate the patient for symptoms indicating the development of pneumothorax, such as dyspnea, tachypnea, anxiety, decreased breathing sounds, or restlessness. A chest x-ray may be ordered to check for the presence of this complication.
 - ◆ Evaluate the patient for symptoms of empyema, such as fever, tachycardia, malaise, or elevated white blood cell count.
 - ◆ Observe the patient's sputum for blood if a biopsy was taken, because large amounts of blood may indicate the development of a problem; a small amount of streaking is expected. Evaluate the patient for signs of bleeding such as tachycardia, hypotension, or restlessness.
 - ◆ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
 - ◆ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
 - ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Instruct the patient to use lozenges or gargle for throat discomfort. Inform the patient of smoking cessation programs as appropriate. Malnutrition is commonly seen in patients with severe respiratory disease for numerous reasons, including fatigue, lack of appetite, and gastrointestinal distress. Adequate intake of vitamins A and C is also important to prevent pulmonary infection and to decrease the extent of lung tissue damage. The importance of following the prescribed diet should be stressed to the patient/caregiver. Educate the patient regarding access to counseling services, as appropriate.
 - ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include arterial/alveolar oxygen ratio, antibodies, anti-glomerular basement membrane, biopsy lung, blood gases, chest x-ray, complete blood count, CT thorax, culture and smear mycobacteria, culture sputum, culture viral, cytology sputum, gram stain, lung perfusion scan, lung ventilation scan, MRI chest, mediastinoscopy, and pulse oximetry.
- ◆ Refer to the Immune and Respiratory System tables at the back of the book for related tests by body system.

B-Type Natriuretic Peptide and Pro-B-Type Natriuretic Peptide

B

SYNONYM/ACRONYM: BNP and Pro-BNP.

SPECIMEN: Plasma (1 mL) collected in a plastic, lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Immunochemiluminometric for BNP; immuno(electro)chemiluminescence for Pro-BNP).

	BNP	Pro-BNP (N-Terminal)
Male	Less than 100 pg/mL	Less than or equal to 60 pg/mL
Female	Less than 100 pg/mL	12–150 pg/mL

DESCRIPTION: The peptides B-type natriuretic peptide (BNP) and atrial natriuretic peptide (ANP) assist in the regulation of fluid balance and blood pressure. BNP, Pro-BNP, and ANP are useful markers in the diagnosis of congestive heart failure. BNP or brain natriuretic peptide, first isolated in the brain of pigs, is a neurohormone synthesized primarily in the ventricles of the human heart in response to increases in ventricular pressure and volume. Circulating levels of BNP and Pro-BNP increase in proportion to the severity of heart failure. A Rapid BNP point-of-care immunoassay may be performed, in which a venous blood sample is collected, placed on a strip, and inserted into a device that measures BNP. Results are completed in 10 to 15 min.

INDICATIONS:

- Assist in determining the prognosis and therapy of patients with heart failure

- Assist in the diagnosis of heart failure
- Assist in differentiating heart failure from pulmonary disease
- Screen for left ventricular dysfunction and therefore need for echocardiography for further assessment

RESULT:

Increased in:

BNP is secreted in response to increased hemodynamic load caused by physiological stimuli as with ventricular stretch or endocrine stimuli from the aldosterone/renin system

- Cardiac inflammation (myocarditis, cardiac allograft rejection)
- Cirrhosis
- Cushing's syndrome
- Heart failure
- Kawasaki disease
- Left ventricular hypertrophy
- Myocardial infarction
- Primary hyperaldosteronism
- Primary pulmonary hypertension
- Renal failure
- Ventricular dysfunction

Decreased in: N/A

CRITICAL VALUES: N/A

**NURSING IMPLICATIONS
AND PROCEDURE****PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to identify congestive heart failure.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A written report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Treatment considerations for CHF:* Ensure that the patient (if not currently taking) is placed on an angiotensin-converting enzyme inhibitor, β -blocker, and diuretic; and monitored with daily weights.
- ▶ *Nutritional considerations:* Instruct patients to consume a variety of foods within the basic food groups, eat foods high in potassium when taking diuretics, eat a diet high in fiber (25 to 35 g/d), maintain a healthy weight, be physically active, limit salt intake to 2000 mg/d, limit alcohol intake, and be a nonsmoker.
- ▶ *Nutritional considerations:* Foods high in potassium include citrus fruits such as bananas, strawberries, oranges; cantaloupes; green leafy vegetables such as spinach and broccoli; dried fruits such as dates, prunes, and raisins; legumes such as peas and pinto beans; nuts and whole grains.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include AST, ANF, calcium and ionized calcium, CRP, CK and isoenzymes, CT scoring, echocardiography, glucose, homocysteine, Holter monitor, LDH and isoenzymes, magnesium, MRI chest, MI scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, and tropinin.
- ▶ Refer to the Cardiovascular System table in the back of the book for related tests by body system.

Calcitonin and Calcitonin Stimulation Tests

SYNONYM/ACRONYM: Thyrocalcitonin, hCT.

SPECIMEN: Serum (3 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

Procedure	Medication Administered	Recommended Collection Times
Calcium and pentagastrin stimulation	Calcium, 2 mg/kg IV for 1 min, followed by pentagastrin 0.5 mcg/kg	4 calcitonin levels—baseline immediately before bolus; and 1 min, 2 min, and 5 min postbolus
Pentagastrin stimulation	Pentagastrin, 0.5 mcg/kg IV push	4 calcitonin levels—baseline immediately before bolus; and 1.5 min, 2 min, and 5 min postbolus

IV = intravenous.

	Conventional Units	SI Units (Conventional Units × 1)
Calcitonin		
<i>Male</i>	Less than 19 pg/mL	Less than 19 ng/L
<i>Female</i>	Less than 14 pg/mL	Less than 14 ng/L
Maximum Response		
After Calcium and Penxtagastrin Stimulation		
<i>Male</i>	Less than 350 pg/mL	Less than 350 ng/L
<i>Female</i>	Less than 94 pg/mL	Less than 94 ng/L
After Pentagastrin Stimulation		
<i>Male</i>	Less than 110 pg/mL	Less than 110 ng/L
<i>Female</i>	Less than 30 pg/mL	Less than 30 ng/L

DESCRIPTION: Calcitonin, also called thyrocalcitonin, is secreted by the parafollicular or C cells of the thyroid gland in response to elevated serum calcium levels. Calcitonin antagonizes the effects of parathyroid hormone and vitamin D so that calcium continues to be laid down in bone rather than reabsorbed into the blood.

Calcitonin also increases renal clearance of magnesium and inhibits tubular reabsorption of phosphates. The net result is that calcitonin decreases the serum calcium level. The pentagastrin (Peptavlon) provocation test and the calcium pentagastrin provocation test are useful for diagnosing medullary thyroid cancer.

INDICATIONS:

- Assist in the diagnosis of hyperparathyroidism
- Assist in the diagnosis of medullary thyroid cancer
- Evaluate altered serum calcium levels
- Monitor response to therapy for medullary thyroid carcinoma
- Predict recurrence of medullary thyroid carcinoma
- Screen family members of patients with medullary thyroid carcinoma (20% have a familial pattern)

RESULT:**Increased in:**

- Alcoholic cirrhosis (**Release of calcium from body stores related to acute instances of malnutrition**)
- Cancer of the breast, lung, and pancreas (**Metastasis of calcitonin-producing cells to other organs**)
- Carcinoid syndrome (**Calcitonin-producing tumor cells**)
- C-cell hyperplasia (**Increased production due to hyperplasia**)
- Chronic renal failure (**Increased excretion of calcium and retention of phosphorus results in release of calcium from body stores; C cells respond to an increase in serum calcium levels**)
- Ectopic secretion (**Especially neuroendocrine origins**)
- Hypercalcemia (any cause) (**Increased production by C cells in response to increased calcium levels**)
- Medullary thyroid cancer (**Overproduction by cancerous cells**)
- MEN Type II (**Calcitonin-producing tumor cells**)
- Pancreatitis (**Related to alcoholism or hypercalcemia**)

- Pernicious anemia (**Related to hypergastrinemia**)
- Pheochromocytoma (**Calcitonin-producing tumor cells**)
- Pregnancy (late) (**Related to increased maternal loss of circulating calcium to developing fetus; release of calcium from maternal stores stimulates increased release of calcitonin**)
- Pseudohypoparathyroidism (**Release of calcium from body stores initiates feedback response from C cells**)
- Thyroiditis (**Calcitonin-producing tumor cells**)
- Zollinger-Ellison syndrome (**related to hypergastrinemia**)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase calcitonin levels include calcium, epinephrine, estrogens, glucagon, oral contraceptives, pentagastrin, and sincalide.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to detect C-cell hyperplasia

of the thyroid gland and to detect and monitor tumors of the thyroid gland.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine, genitourinary, and musculoskeletal systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min; a few extra minutes are required to administer the stimulation tests. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ The patient should fast for 10 to 12 hr before specimen collection. Protocols may vary from facility to facility.
- ▶ There are no fluid or medication restrictions unless by medical direction.
- ▶ Prepare an ice slurry in a cup or plastic bag to have ready for immediate transport of the specimen to the laboratory. Prechill the collection tube in the ice slurry.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions and pretesting preparations; assure that food has been restricted for at least 10 to 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.

Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a prechilled tube.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ The sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag. Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet as directed by the HCP.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, biopsy thyroid, calcium, cancer antigens, catecholamines, complete blood count, gastrin stimulation test,

magnesium, metanephrines, PTH, parathyroid scan, phosphorus, thyroglobulin, thyroid scan, TSH, US thyroid and parathyroid, and vitamin D.

Refer to the Endocrine, Genitourinary, and Musculoskeletal System tables at the back of the book for related tests by body system.

Calcium, Blood

SYNONYM/ACRONYM: Total calcium, Ca.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 0.25)
Cord	8.2–11.2 mg/dL	2.05–2.80 mmol/L
0–10 d	7.6–10.4 mg/dL	1.90–2.60 mmol/L
11 d–2 y	9.0–11.0 mg/dL	2.25–2.75 mmol/L
3–12 y	8.8–10.8 mg/dL	2.20–2.70 mmol/L
13–18 y	8.4–10.2 mg/dL	2.10–2.55 mmol/L
Adult	8.2–10.2 mg/dL	2.05–2.55 mmol/L
Adult older than 90 y	8.2–9.6 mg/dL	2.05–2.40 mmol/L

DESCRIPTION: Calcium, the most abundant cation in the body, participates in almost all of the vital processes. Calcium concentration is largely regulated by the parathyroid glands and by the action of vitamin D. Of the body's calcium reserves, 98% to 99% is stored in the teeth and skeleton. Calcium values are higher in children because of growth and active bone formation. About 45% of the total amount of blood calcium circulates as free ions that participate in

coagulation, neuromuscular conduction, intracellular regulation, glandular secretion, and control of skeletal and cardiac muscle contractility. The remaining calcium is bound to circulating proteins (40% bound mostly to albumin) and anions (15% bound to anions such as bicarbonate, citrate, phosphate, and lactate) and plays no physiological role. Calcium values can be adjusted up or down by 0.8 mg/dL for every 1 g/dL that albumin is greater than or less than 4 g/dL.

Calcium and phosphorus levels are inversely proportional.

Fluid and electrolyte imbalances are often seen in patients with serious illness or injury; in these clinical situations, the normal homeostatic balance of the body is altered. During surgery or in the case of a critical illness, bicarbonate, phosphate, and lactate concentrations can change dramatically. Therapeutic treatments may also cause or contribute to electrolyte imbalance. This is why total calcium values can sometimes be misleading. Abnormal calcium levels are used to indicate general malfunctions in various body systems. Ionized calcium is used in more specific conditions (see monograph titled “Calcium, Ionized”).

Calcium values should be interpreted in conjunction with results of other tests. Normal calcium with an abnormal phosphorus value indicates impaired calcium absorption (possibly because of altered parathyroid hormone level or activity). Normal calcium with an elevated urea nitrogen value indicates possible hyperparathyroidism (primary or secondary). Normal calcium with decreased albumin value is an indication of hypercalcemia (high calcium levels). The most common cause of hypocalcemia (low calcium levels) is hypoalbuminemia. The most common causes of hypercalcemia are hyperparathyroidism and cancer (with or without bone metastases).

INDICATIONS:

- Detect parathyroid gland loss after thyroid or other neck surgery, as indicated by decreased levels

- Evaluate cardiac arrhythmias and coagulation disorders to determine if altered serum calcium level is contributing to the problem
- Evaluate the effects of various disorders on calcium metabolism, especially diseases involving bone
- Monitor the effectiveness of therapy being administered to correct abnormal calcium levels, especially calcium deficiencies
- Monitor the effects of renal failure and various drugs on calcium levels

RESULT:

Increased in:

- Acidosis (***Exchange of electrolytes is affected. Long-standing acidosis can result in osteoporosis and release of calcium into circulation***)
- Acromegaly (***Vitamin D metabolism is affected, resulting in increased calcium***)
- Addison's disease (***Related to adrenal gland dysfunction; decreased blood volume and dehydration occur in the absence of aldosterone***)
- Cancers (bone, Burkitt's lymphoma, Hodgkin's lymphoma, leukemia, myeloma, and metastases from other organs)
- Dehydration (***Decrease in fluid portion of blood causes an overall increase in most constituents***)
- Hyperparathyroidism (***PTH and vitamin D increase circulating calcium levels***)
- Idiopathic hypercalcemia of infancy
- Lung disease (tuberculosis, histoplasmosis, coccidioidomycosis, berylliosis) (***Macrophages in the epithelium interfere with Vitamin D regulation by converting it to its active form. Vitamin D increases circulating calcium levels***)

- Malignant disease without bone involvement (**Some cancers, e.g., squamous cell carcinoma of the lung and kidney cancer, produce PTH-related peptide that increases calcium levels**)
- Milk-alkali syndrome (Burnett's syndrome) (**Excessive intake of calcium-containing milk or antacids can increase calcium levels**)
- Paget's disease (**Calcium is released from bone**)
- Pheochromocytoma (**Hyperparathyroidism related to MEN 2A syndrome associated with some pheochromocytomas; PTH increases calcium levels**)
- Polycythemia vera (**Related to dehydration; decreased blood volume due to excessive production of red blood cells**)
- Renal transplant (**Imbalances in electrolytes is a common post-transplant issue**)
- Sarcoidosis (**Macrophages in the granulomas interfere with vitamin D regulation by converting it to its active form; vitamin D increases circulating calcium levels**)
- Thyrotoxicosis (**Related to increased bone turnover and release of calcium into the blood**)
- Vitamin D toxicity (**Vitamin D increases circulating calcium levels**)
- Cystinosis (**Hereditary disorder of the renal tubules that results in excessive calcium loss**)
- Hepatic cirrhosis (**Related to impaired metabolism of vitamin D and calcium**)
- Hyperphosphatemia (**Phosphorus and calcium have an inverse relationship**)
- Hypoalbuminemia (**Albumin is an important carrier protein**)
- Hypomagnesemia (**Lack of magnesium inhibits PTH and thereby decreases calcium levels**)
- Hypoparathyroidism (congenital, idiopathic, surgical) (**Related to lack of PTH**)
- Inadequate nutrition
- Leprosy (**Related to increased bone retention**)
- Long-term anticonvulsant therapy (**These medications block calcium channels and interfere with calcium transport**)
- Malabsorption (celiac disease, tropical sprue, pancreatic insufficiency) (**Insufficient absorption**)
- Massive blood transfusion (**Citrate preservative in blood product chelates or binds calcium and removes it from circulation**)
- Neonatal prematurity
- Osteomalacia (advanced) (**Bone loss is so advanced there is little calcium remaining to be released into circulation**)
- Renal tubular disease (**Related to decreased synthesis of vitamin D**)
- Vitamin D deficiency (rickets) (**Lack of vitamin D results in decreased calcium metabolism**)

Decreased in:

- Acute pancreatitis (**Complication of pancreatitis related to hypoalbuminemia and calcium binding by excessive fats**)
- Alcoholism (**Related to insufficient nutrition**)
- Alkalosis (**Increased blood pH causes intracellular uptake of calcium to increase**)
- Chronic renal failure (**Related to decreased synthesis of vitamin D**)

CRITICAL VALUES:

Less than 7 mg/dL

Greater than 12 mg/dL (some patients can tolerate higher concentrations)

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

Observe the patient for symptoms of critically decreased or elevated calcium levels. Hypocalcemia is evidenced by convulsions, arrhythmias, changes in electrocardiogram (ECG) in the form of prolonged ST segment and Q-T interval, facial spasms (positive Chvostek's sign), tetany, muscle cramps, numbness in extremities, tingling, and muscle twitching (positive Trousseau's sign). Possible interventions include seizure precautions, increased frequency of ECG monitoring, and administration of calcium or magnesium.

Severe hypercalcemia is manifested by polyuria, constipation, changes in ECG (shortened ST segment), lethargy, muscle weakness, apathy, anorexia, headache, and nausea and ultimately may result in coma. Possible interventions include the administration of normal saline and diuretics to speed up excretion or administration of calcitonin or steroids to force the circulating calcium into the cells.

INTERFERING FACTORS:

- Drugs that may increase calcium levels include anabolic steroids, some antacids, calcitriol, calcium salts, danazol, diuretics (long-term), ergocalciferol, isotretinoin, lithium, oral contraceptives, parathyroid extract, parathyroid hormone, prednisone, progesterone, tamoxifen, vitamin A, and vitamin D.
- Drugs that may decrease calcium levels include albuterol, alprostadil, aminoglycosides, anticonvulsants, calcitonin, diuretics (initially), gastrin, glucagon, glucocorticoids, glucose, insulin, laxatives (excessive use), magnesium salts, methicillin, phosphates, plicamycin, sodium sulfate (given IV), tetracycline (in pregnancy), trazodone, and viomycin.
- Calcium exhibits diurnal variation; serial samples should be collected at the same time of day for comparison.
- Venous hemostasis caused by prolonged use of a tourniquet during venipuncture can falsely elevate calcium levels.
- Patients on ethylenediaminetetraacetic acid (EDTA) therapy (chelation) may show falsely decreased calcium values.
- Hemolysis and icterus cause false-positive results because of interference from biological pigments.
- Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, falsely decreasing the result. There is also the potential of contaminating the sample with the substance of interest, if it is present in the IV solution, falsely increasing the result.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to investigate various conditions indicated by abnormally increased or decreased calcium levels.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's cardiovascular, gastrointestinal, genitourinary, hematopoietic, hepatobiliary, and musculoskeletal systems, as well as results of previously performed laboratory tests, diagnostic, and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Nutritional considerations:** Patients with abnormal calcium values should be informed that daily intake of calcium is important even though body stores in the bones can be called on to supplement circulating levels. Dietary calcium can be obtained from animal or plant sources. Milk and milk products, sardines, clams, oysters, salmon, rhubarb, spinach, beet greens, broccoli, kale, tofu, legumes, and fortified orange juice are high in calcium. Milk and milk products also contain vitamin D and lactose, which assist calcium

absorption. Cooked vegetables yield more absorbable calcium than raw vegetables. Patients should be informed of the substances that can inhibit calcium absorption by irreversibly binding to some of the calcium, making it unavailable for absorption, such as oxalates, which naturally occur in some vegetables (e.g., beet greens, collards, leeks, okra, parsley, quinoa, spinach, Swiss chard) and are found in tea; phytic acid, found in some cereals (e.g., wheat bran, wheat germ); phosphoric acid, found in dark cola; and insoluble dietary fiber (in excessive amounts). Excessive protein intake can also negatively affect calcium absorption, especially if it is combined with foods high in phosphorus and in the presence of a reduced dietary calcium intake.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ACTH, albumin, aldosterone, ALP, biopsy bone marrow, BMD, bone scan, calcitonin, calcium ionized, urine calcium, calculus kidney stone analysis, catecholamines, chloride, collagen cross-linked telopeptides, complete blood count, CT pelvis, CT spine, cortisol, CK and isoenzymes, DHEA, fecal fat, glucose, HVA, magnesium, metanephrines, osteocalcin, PTH, phosphorus, potassium, protein total, radiography bone, renin, sodium, thyroid scan, thyroxine, US thyroid and parathyroid, UA, and vitamin D.
- Refer to the Cardiovascular, Gastrointestinal, Genitourinary, Hematopoietic, Hepatobiliary, and Musculoskeletal System tables at the back of the book for related tests by body system.

Calcium, Ionized

SYNONYM/ACRONYM: free calcium, unbound calcium, Ca⁺⁺, Ca²⁺.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Specimen should be transported tightly capped and remain unopened until testing. Exposure of serum to room air changes the pH of the specimen due to the release of carbon dioxide and can cause erroneous results.

REFERENCE VALUE: (Method: Ion-selective electrode)

	Conventional Units	SI Units (Conventional Units × 0.25)
Whole blood		
1–5 d	4.20–5.84 mg/dL	1.05–1.46 mmol/L
Adult	4.60–5.08 mg/dL	1.12–1.32 mmol/L
Plasma		
Adult	4.12–4.92 mg/dL	1.03–1.23 mmol/L
Serum		
1–18 yr	4.8–5.52 mg/dL	1.2–1.38 mmol/L
Adult	4.64–5.28 mg/dL	1.16–1.32 mmol/L

DESCRIPTION: Calcium is the most abundant cation in the body and participates in almost all vital body processes (see other calcium monographs). Circulating calcium is found in the free or ionized form; bound to organic anions such as lactate, phosphate, or citrate; and bound to proteins such as albumin. Ionized calcium is the physiologically active form of circulating calcium. About half of the total amount of calcium circulates as free ions that participate in blood coagulation, neuromuscular conduction, intracellular regulation, glandular secretion, and control of skeletal and cardiac muscle contractility. Calcium levels are regulated largely by the

parathyroid glands and by vitamin D. Compared to total calcium level, ionized calcium is a better measurement of calcium metabolism. Ionized calcium levels are not influenced by protein concentrations, as seen in patients with chronic renal failure, nephrotic syndrome, malabsorption, and multiple myeloma. Levels are also not affected in patients with metabolic acid-base balance disturbances. Elevations in ionized calcium may be seen when the total calcium is normal. Measurement of ionized calcium is useful to monitor patients undergoing cardiothoracic surgery or organ transplantation. It is also useful in the evaluation of patients in cardiac arrest.

INDICATIONS:

- Detect ectopic parathyroid hormone–producing neoplasms
- Evaluate the effect of protein on calcium levels
- Identify individuals with hypocalcemia
- Identify individuals with toxic levels of vitamin D
- Investigate suspected hyperparathyroidism
- Monitor patients with renal failure or organ transplantation, in whom secondary hyperparathyroidism may be a complication
- Monitor patients with sepsis or magnesium deficiency

RESULT:**Increased in:**

- Hyperparathyroidism (**Related to increased PTH**)
- Parathyroid hormone–producing neoplasms (**PTH increases calcium levels**)
- Vitamin D toxicity (**Increases absorption of calcium**)

Decreased in:

- Burns, severe (**Related to increased amino acid release**)
- Hypoparathyroidism (primary) (**Related to decreased PTH**)
- Magnesium deficiency (**Inhibits release of PTH**)
- Multiple organ failure
- Pancreatitis (**Associated with saponification or binding of calcium to fats in tissue surrounding the pancreas**)
- The postdialysis period (**Result of low-calcium dialysate administration**)
- The postsurgical period (i.e., major surgeries) (**Related to decreased PTH**)
- The post-transfusion period (**Result of the use of citrated blood product preservative (calcium chelator)**)
- Premature infants with hypoproteinemia and acidosis (**Related to**

alterations in transport protein levels)

- Pseudohypoparathyroidism (**Related to decreased PTH**)
- Sepsis (**Related to decreased PTH**)
- Trauma (**Related to decreased PTH**)
- Vitamin D deficiency (**Decreased absorption of calcium**)

CRITICAL VALUES:

Less than 3.2 mg/dL

Greater than 6.2 mg/dL

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

Observe the patient for symptoms of critically decreased or elevated calcium levels. Hypocalcemia is evidenced by convulsions, arrhythmias, changes in electrocardiogram (ECG) in the form of prolonged ST segment and Q-T interval, facial spasms (positive Chvostek's sign), tetany, muscle cramps, numbness in extremities, tingling, and muscle twitching (positive Trousseau's sign). Possible interventions include seizure precautions, increased frequency of ECG monitoring, and administration of calcium or magnesium.

Severe hypercalcemia is manifested by polyuria, constipation, changes in ECG (shortened ST segment), lethargy, muscle weakness, apathy, anorexia, headache, and nausea, and ultimately may result in coma. Possible interventions include the administration of normal saline and diuretics to speed up excretion or administration of calcitonin or steroids to force the circulating calcium into the cells.

INTERFERING FACTORS:

- Drugs that may increase calcium levels include antacids (some), calcitriol, and lithium.

- Drugs that may decrease calcium levels include calcitonin, citrates, foscarnet, and pamidronate (initially).
 - Calcium exhibits diurnal variation; serial samples should be collected at the same time of day for comparison.
 - Venous hemostasis caused by prolonged use of a tourniquet during venipuncture can falsely elevate calcium levels.
 - Patients on ethylenediaminetetraacetic acid (EDTA) therapy (chelation) may show falsely decreased calcium values.
 - Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, falsely decreasing the result. There is also the potential of contaminating the sample with the substance of interest, if it is present in the IV solution, falsely increasing the result.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
 - ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
 - ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
 - ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture and, without using a tourniquet, collect the specimen.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ The specimen should be stored under anaerobic conditions after collection to prevent the diffusion of gas from the specimen. Falsely decreased values result from unstoppered specimens. Promptly transport the specimen to the laboratory for processing and analysis.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to investigate various conditions indicated by abnormally increased or decreased levels of ionized calcium.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, gastrointestinal, genitourinary, hematopoietic, hepatobiliary, and musculoskeletal systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that could interfere with test results.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Patients with abnormal calcium values should be informed that daily intake of calcium is important even though body stores in the bones can be called on to supplement circulating levels. Dietary calcium

can be obtained from animal or plant sources. Milk and milk products, sardines, clams, oysters, salmon, rhubarb, spinach, beet greens, broccoli, kale, tofu, legumes, and fortified orange juice are high in calcium. Milk and milk products also contain vitamin D and lactose, which assist calcium absorption. Cooked vegetables yield more absorbable calcium than raw vegetables. Patients should be informed of the substances that can inhibit calcium absorption by irreversibly binding to some of the calcium, making it unavailable for absorption, such as oxalates, which naturally occur in some vegetables (e.g., beet greens, collards, leeks, okra, parsley, quinoa, spinach, Swiss chard) and are found in tea; phytic acid, found in some cereals (e.g., wheat bran, wheat germ); phosphoric acid, found in dark cola; and insoluble dietary fiber (in excessive amounts). Excessive protein intake can also negatively affect calcium absorption, especially if it is combined with foods high in phosphorus and in the presence of a reduced dietary calcium intake.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include albumin, ALP, calcitonin, calcium, calculus kidney stone panel, gastrin and gastrin stimulation, magnesium, PTH, parathyroid scan, phosphorus, potassium, protein total, sodium, thyroglobulin, US thyroid and parathyroid, UA, and vitamin D.
- ◆ Refer to the Cardiovascular, Gastrointestinal, Genitourinary, Hematopoietic, Hepatobiliary, and Musculoskeletal System tables at the back of the book for related tests by body system.

Calcium, Urine

SYNONYM/ACRONYM: N/A

SPECIMEN: Urine (5 mL) from an unpreserved random or timed specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units*	SI Units (Conventional Units × 0.25)*
Infant and child	Up to 6 mg/kg per 24 hr	Up to 0.15 mmol/kg per 24 hr
Adult on average diet	100–300 mg/24 hr	2.5–7.5 mmol/24 hr

*Values depend on diet. Average daily intake of calcium: 600–800 mg/24 hr.

DESCRIPTION: Regulating electrolyte balance is a major function of the kidneys. In normally functioning kidneys, urine levels increase when serum levels are high and decrease when serum levels are low to maintain homeostasis. Analyzing urinary electrolyte levels can provide important clues to the functioning of the kidneys and other major organs. Tests for calcium in urine usually involve timed urine collections during a 12- or 24-hr period. Measurement of random specimens may also be requested. Urinary calcium excretion may also be expressed as calcium-to-creatinine ratio: In a healthy individual with constant muscle mass, the ratio is less than 0.14.

INDICATIONS:

- Assist in establishing the presence of kidney stones
- Evaluate bone disease
- Evaluate dietary intake and absorption
- Evaluate renal loss
- Monitor patients on calcium replacement

RESULT:

Increased in:

- Acromegaly (*Vitamin D metabolism is affected, resulting in increased calcium*)
- Diabetes (*Related to increased loss from damaged kidneys*)
- Fanconi's syndrome (*Hereditary or acquired disorder of the renal tubules that results in excessive calcium loss*)
- Glucocorticoid excess (*Glucocorticoids decrease the gastrointestinal absorption of calcium and increase urinary excretion*)

- Hepatolenticular degeneration (Wilson's disease) (*Related to renal damage and excessive electrolyte loss*)
- Hyperparathyroidism (*Increased levels of PTH result in increased calcium levels*)
- Hyperthyroidism (*Increased bone turnover; excess circulating calcium is excreted by the kidneys*)
- Idiopathic hypercalciuria
- Immobilization (*Related to disruption in calcium homeostasis and bone loss*)
- Kidney stones (*Excessive urinary calcium contributes to the formation of kidney stones*)
- Leukemia and lymphoma (some instances)
- Myeloma (*Calcium is released from damaged bone; excess circulating calcium is excreted by the kidneys*)
- Neoplasm of the breast or bladder (*Some cancers secrete PTH or PTH-related peptide that increases calcium levels*)
- Osteitis deformans (*Calcium is released from damaged bone; excess circulating calcium is excreted by the kidneys*)
- Osteolytic bone metastases (carcinoma, sarcoma) (*Calcium is released from damaged bone; excess circulating calcium is excreted by the kidneys*)
- Osteoporosis (*Calcium is released from damaged bone; excess circulating calcium is excreted by the kidneys*)
- Paget's disease
- Renal tubular acidosis (*Calcium is released from damaged bone; excess circulating calcium is excreted by the kidneys*)
- Sarcoidosis (*Macrophages in the granulomas interfere with Vitamin D regulation by converting it to its active form.*)

Vitamin D increases circulating calcium levels and excess is excreted by the kidneys)

- Schistosomiasis
- Thyrotoxicosis (**Increased bone turnover; excess circulating calcium is excreted by the kidneys**)
- Vitamin D intoxication (**Increases calcium metabolism; excess is excreted by the kidneys**)

Decreased in:

- Hypocalcemia (other than renal disease)
- Hypocalciuric hypercalcemia (familial, nonfamilial)
- Hypoparathyroidism (**PTH instigates release of calcium; if PTH levels are low, calcium levels will be decreased**)
- Hypothyroidism
- Malabsorption (celiac disease, tropical sprue)
- Malignant bone neoplasm
- Nephrosis and acute nephritis (**Related to decreased synthesis of vitamin D**)
- Osteoblastic metastases
- Osteomalacia (**Related to vitamin D deficiency**)
- Pre-eclampsia
- Pseudohypoparathyroidism
- Renal osteodystrophy
- Rickets (**Deficiency in vitamin D results in decreased calcium levels**)
- Vitamin D deficiency (**Deficiency in vitamin D results in decreased calcium levels**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that can increase urine calcium levels include acetazolamide, ammonium chloride, asparaginase, calcitonin, calcitriol, corticosteroids, corticotropin, dexamethasone, diuretics (initially), ergocalciferol, ethacrynic acid, mannitol (initially), meralluride,

mercaptomerin, mersalyl, nandrolone, parathyroid extract, parathyroid hormone, plicamycin, sodium sulfate, sulfates, triamterene, viomycin, and vitamin D.

- Drugs that can decrease urine calcium levels include angiotensin, bicarbonate, calcitonin, citrates, diuretics (chronic), lithium, neomycin, oral contraceptives, and spironolactone.
- Failure to collect all the urine and store the specimen properly during the 24-hr test period invalidates the results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to indicate sufficiency of dietary calcium intake and rate of absorption. Urine calcium levels are also used to assess bone resorption, renal stones, and renal loss of calcium.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine, genitourinary, and musculoskeletal systems and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological

support before, during, and after the procedure.

- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ There are no fluid or medication restrictions unless by medical direction.
- ▶ Instruct the patient to follow a normal calcium diet for at least 4 days before test. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that a normal calcium diet has been followed for at least 4 days prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):

- ▶ Obtain urine specimen in a properly labeled plastic collection container and immediately transport urine. If an indwelling catheter is in place, it may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge

needle and syringe. Transfer urine to a plastic container.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started, and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection began.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than the recorded output, some urine may have been discarded, invalidating the test.
- ▶ Include on the collection container's label the amount of urine collected and test start and stop times. Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet as directed by the HCP.
- ▶ **Nutritional considerations:** Increased urine calcium levels may be associated with kidney stones. Educate the patient, if appropriate, as to the importance of drinking a sufficient amount of water when kidney stones are suspected.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, albumin, aldosterone, ALP, biopsy bone marrow, BMD, bone scan, calcitonin, calcium ionized, calculus kidney stone analysis, catecholamines, chloride, collagen cross-linked telopeptides, complete blood count, CT pelvis, CT spine, cortisol, CK and isoenzymes, DHEA, fecal fat, glucose, HVA, magnesium, metanephrines, osteocalcin, oxalate, PTH, phosphorus, potassium, protein total, radiography bone, renin, sodium, thyroid scan, thyroxine, US thyroid and parathyroid, UA, uric acid, and vitamin D.
- ▶ Refer to the Endocrine, Genitourinary, and Musculoskeletal System tables at the end of the book for related tests by body system.

Calculus, Kidney Stone Panel

SYNONYM/ACRONYM: Kidney stone analysis, nephrolithiasis analysis.

SPECIMEN: Kidney stones.

REFERENCE VALUE: (Method: Infrared spectrometry) None detected.

DESCRIPTION: Renal calculi (kidney stones) are formed by the crystallization of calcium oxalate (most common), magnesium ammonium phosphate, calcium phosphate, uric acid, and cystine. Formation of stones may be due to reduced urine flow and excessive amounts of the previously mentioned insoluble substances. The presence of stones is confirmed by diagnostic visualization or passing of the stones in the urine. The chemical nature of the stones is confirmed qualitatively.

INDICATIONS: Identify substances present in renal calculi

RESULT:**Positive findings in:**

- **Presence of renal calculi**

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may increase the formation of urine calculi include probenecid and vitamin D.
- Adhesive tape should not be used to attach stones to any transportation or collection container, because the adhesive interferes with infrared spectrometry.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify the presence of kidney stones.
- ▶ Obtain a history of the patient's complaints, especially hematuria, recurrent urinary tract infection, and abdominal pain. Also, obtain a list of known allergens.
- ▶ Obtain a history of the patient's genitourinary system and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be some discomfort during the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
- ▶ The patient presenting with symptoms indicating the presence of kidney stones may be provided with a device to strain the urine. The patient should be informed to transfer any particulate matter remaining in the strainer into the specimen collection container provided. Stones removed by the health care provider (HCP) should be placed in the appropriate collection container.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Inform the patient with kidney stones that the likelihood of recurrence is high. Educate the patient regarding risk factors that contribute to the likelihood of kidney stone formation, including family history, osteoporosis, urinary tract infections, gout, magnesium deficiency, Crohn's disease with prior resection, age, gender (males are two to three times more likely to develop stones than females), and climate.
- ▶ *Dietary considerations:* Nutritional therapy is indicated for individuals identified as being at high risk for developing kidney stones. Educate the patient that diets rich in protein, salt, and oxalates increase the risk of stone formation. Adequate fluid intake should be encouraged.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Follow-up testing of urine may be requested, but usually not for 1 mo after the stones have passed or been removed. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CT abdomen, calcium, creatinine clearance, culture bacterial urine, cystoscopy, IVP, KUB, magnesium, oxalate, phosphorus, renogram, retrograde ureteropyelography, US kidney, uric acid, and UA.
- ▶ Refer to the Genitourinary System table at the end of the book for related tests by body system.

Capsule Endoscopy

SYNONYM/ACRONYM: Pill GI endoscopy.

AREA OF APPLICATION: Esophagus, stomach, upper duodenum, and small bowel.

CONTRAST: None.

DESCRIPTION: This outpatient procedure involves ingesting a small (size of a large vitamin pill) capsule that is wireless and contains a small video camera that will pass naturally through the digestive system while taking pictures of the intestine. The capsule is 11 mm by 30 mm and contains a camera, light source, radio transmitter, and battery. The patient swallows the capsule, and the camera takes and transmits two images per second. The images are transmitted to a recording device, which saves all images for review later by a health care practitioner (HCP). This device is approximately the size of a personal compact disc player. The recording device is worn on a belt around the patient's waist, and the video images are transmitted to aerials taped to the body and stored on the device. After 8 hr, the device is removed and returned to the HCP for processing. Thousands of images are downloaded onto a computer for viewing by a HCP specialist. The capsule is disposable and will be excreted naturally in the patient's bowel movements. In the rare case that it is not excreted naturally, it will need to be removed endoscopically or surgically.

INDICATIONS:

- Assist in differentiating between benign and neoplastic tumors
- Detect gastric or duodenal ulcers
- Detect gastrointestinal tract (GI) inflammatory disease
- Determine the presence and location of GI bleeding and vascular abnormalities
- Evaluate the extent of esophageal injury after ingestion of chemicals
- Evaluate stomach or duodenum after surgical procedures
- Evaluate suspected gastric obstruction
- Identify Crohn's disease, infectious enteritis, and celiac sprue
- Identify source of chronic diarrhea
- Investigate the cause of abdominal pain, celiac syndrome, and other malabsorption syndromes

RESULT:

Normal findings in:

- Esophageal mucosa is normally yellow-pink. At about 9 in. from the incisor teeth, a pulsation indicates the location of the aortic arch. The gastric mucosa is orange-red and contains rugae. The proximal duodenum is reddish and contains a few longitudinal folds, whereas the distal duodenum has circular folds lined with villi. No abnormal structures or functions are observed in the esophagus, stomach, or duodenum.

Abnormal findings in:

- Achalasia
- Acute and chronic gastric and duodenal ulcers
- Crohn's disease, infectious enteritis, and celiac sprue
- Diverticular disease
- Duodenal cancer, diverticula, and ulcers
- Duodenitis
- Esophageal or pyloric stenosis
- Esophageal varices
- Esophagitis or strictures
- Gastric cancer, tumors, and ulcers
- Gastritis
- Hiatal hernia
- Mallory-Weiss syndrome
- Perforation of the esophagus, stomach, or small bowel
- Polyps
- Small bowel tumors
- Strictures
- Tumors (benign or malignant)

CRITICAL VALUES: N/A**INTERFERING FACTORS:*****This procedure is contraindicated for:***

- Patients who have had surgery involving the stomach or duodenum, which can make locating the duodenal papilla difficult
- Patients with a bleeding disorder
- Patients with unstable cardiopulmonary status, blood coagulation defects, or cholangitis, unless the patient received prophylactic antibiotic therapy before the test (otherwise the examination must be rescheduled)
- Patients with unstable cardiopulmonary status, blood coagulation defects, known aortic arch aneurysm, large esophageal Zenker's diverticulum, recent GI surgery, esophageal varices, or known esophageal perforation

Factors that may impair clear imaging:

- Gas or feces in the GI tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure

Other considerations:

- The patient should not be near any electromagnetic source, such as magnetic resonance imaging (MRI) or amateur (ham) radio equipment.
- Undergoing an MRI during the procedure may result in serious damage to the patient's intestinal tract or abdomen. The patient should contact his or her HCP for evaluation prior to any other procedure.
- Delayed capsule transit times may be a result of narcotic use, somatostatin use, gastroparesis, or psychiatric illness.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses the GI tract.
- ♦ Obtain a history of the patient's complaints including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, and dyes.
- ♦ Obtain a history of results of the patient's previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Ensure that this procedure is performed before an upper GI series or barium swallow.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical

direction for the appropriate number of days prior to a surgical procedure. Note time and date of last dose.

- ▶ Review the procedure with the patient. Address concerns about pain and explain that no pain will be experienced during the procedure. Inform the patient that the procedure is begun in a GI lab or office, usually by a HCP or support staff, and that it takes approximately 30 to 60 min to begin the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to stop taking medications that have a coating effect, such as sucralfate and Pepto-Bismol, 3 days before the procedure.
- ▶ Instruct the patient to abstain from the use of tobacco products for 24 hr prior to the procedure.
- ▶ Instruct the patient to start a liquid diet on the day before the procedure. From 10 p.m. the evening before the procedure, the patient should not eat or drink except for necessary medication with a sip of water. Instruct the patient to take a standard bowel prep the night before the procedure. Protocols may vary from facility to facility.
- ▶ Instruct the patient not to take any medication for 2 hr prior to the procedure.
- ▶ Inform the patient that there is a chance of intestinal obstruction associated with the procedure.
- ▶ Instruct the patient to wear loose, two-piece clothing on the day of the procedure. This assists with the placement of the sensors on the patient's abdomen.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions and pretesting preparations for at least 8 hr prior to the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Obtain accurate height, weight, and abdominal girth measurements prior to beginning the examination.

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Ask the patient to ingest the capsule with a full glass of water. The water may have simethicone in it to reduce gastric and bile bubbles.
- ▶ After ingesting the capsule, the patient should not eat or drink for at least 2 hr. After 4 hr, the patient may have a light snack.
- ▶ After ingesting the capsule and until it is excreted, the patient should not be near any source of powerful electromagnetic fields, such as MRI or amateur (ham) radio equipment.
- ▶ The procedure lasts approximately 8 hr.
- ▶ Instruct the patient not to disconnect the equipment or remove the belt at any time during the test.
- ▶ If the data recorder stops functioning, instruct the patient to record the time and the nature of any event such as eating or drinking.
- ▶ Instruct the patient to keep a timed diary for the day detailing the food and liquids ingested and symptoms during the recording period.
- ▶ Instruct the patient to avoid any strenuous physical activity, bending, or stooping during the test.

POST-TEST:

- ▶ Instruct the patient to resume normal activity, medication, and diet after the test is ended, or as tolerated after the examination, as directed by the HCP.
- ▶ Instruct the patient to remove the recorder and return it to the HCP.
- ▶ Patients are asked to verify the elimination of the capsule, but not to retrieve the capsule.
- ▶ Inform the patient that the capsule is a single-use device that does not harbor any environmental hazards.
- ▶ Emphasize that any abdominal pain, fever, nausea, vomiting, or difficulty breathing must be immediately reported to the HCP.
- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's

lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include barium enema, barium swallow, biopsy intestinal, cancer antigens, colonoscopy, CT abdomen, CT colonoscopy, esophageal monometry, esophagogastroduodenoscopy, fecal analysis, folate, gastric acid emptying scan, gastric acid stimulation test, gastrin, *Helicobacter pylori*, KUB studies, MRI abdomen, PET pelvis, proctosigmoidoscopy, upper GI and small bowel series, US abdomen, and vitamin B₁₂.
- ▶ Refer to the Gastrointestinal System table in the back of the book for related tests by body system.

Carbon Dioxide

SYNONYM/ACRONYM: CO₂ combining power, CO₂, tCO₂.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube, plasma (1 mL) collected in a green-top (lithium or sodium heparin) tube; or whole blood (1 mL) collected in a green-top (lithium or sodium heparin) tube or heparinized syringe.

REFERENCE VALUE: (Method: Colorimetry, enzyme assay, or pCO₂ electrode)

Carbon Dioxide	Conventional Units	SI Units (Conventional Units × 1)
Plasma or serum (venous)		
<i>Infant-2 yr</i>	13-29 mEq/L	13-29 mmol/L
<i>2 yr and older</i>	23-29 mEq/L	23-29 mmol/L
Whole blood (venous)		
<i>Infant-2 yr</i>	18-28 mEq/L	18-28 mmol/L
<i>2 yr and older</i>	22-26 mEq/L	22-26 mmol/L

DESCRIPTION: Serum or plasma carbon dioxide (CO₂) measurement is usually done as part of an electrolyte panel. Total CO₂ (tCO₂) is an important

component of the body's buffering capability, and measurements are used mainly in the evaluation of acid-base balance. It is important to understand the differences

between $t\text{CO}_2$ (CO_2 content) and CO_2 gas ($p\text{CO}_2$). *Total CO_2* reflects the majority of CO_2 in the body, mainly in the form of bicarbonate (HCO_3^-); is present as a base; and is regulated by the kidneys. CO_2 gas contributes little to the $t\text{CO}_2$ level, is acidic, and is regulated by the lungs (see monograph titled “Blood Gases”).

CO_2 provides the basis for the principal buffering system of the extracellular fluid system, which is the bicarbonate–carbonic acid buffer system. CO_2 circulates in the body either bound to protein or physically dissolved. Constituents in the blood that contribute to $t\text{CO}_2$ levels are bicarbonate (HCO_3^-), carbamino compounds, and carbonic acid (carbonic acid includes undissociated carbonic acid and dissolved CO_2). Bicarbonate is the second largest group of anions in the extracellular fluid (chloride being the largest group of extracellular anions). $t\text{CO}_2$ levels closely reflect bicarbonate levels in the blood, because 90% to 95% of CO_2 circulates as HCO_3^- .

INDICATIONS:

- Evaluate decreased venous CO_2 in the case of compensated metabolic acidosis
- Evaluate increased venous CO_2 in the case of compensated metabolic alkalosis
- Monitor decreased venous CO_2 as a result of compensated respiratory alkalosis
- Monitor increased venous CO_2 as a result of compensation for respiratory acidosis secondary to significant respiratory system infection or cancer; decreased respiratory rate

RESULT:

Increased in:

Interpretation requires clinical information and evaluation of other electrolytes

- Acute intermittent porphyria (*Related to severe vomiting associated with acute attacks*)
- Airway obstruction (*Related to impaired elimination from weak breathing responses*)
- Asthmatic shock (*Related to impaired elimination from abnormal breathing responses*)
- Brain tumor (*Related to abnormal blood circulation*)
- Bronchitis (chronic) (*Related to impaired elimination from weak breathing responses*)
- Cardiac disorders (*Related to lack of blood circulation*)
- Depression of respiratory center (*Related to impaired elimination from weak breathing responses*)
- Electrolyte disturbance (severe) (*Response to maintain acid-base balance*)
- Emphysema (*Related to impaired elimination from weak breathing responses*)
- Hypothyroidism (*Related to impaired elimination from weak breathing responses*)
- Hypoventilation (*Related to impaired elimination from weak breathing responses*)
- Metabolic alkalosis (*Various causes; excessive vomiting*)
- Myopathy (*Related to impaired ventilation*)
- Pneumonia (*Related to impaired elimination from weak breathing responses*)
- Poliomyelitis (*Related to impaired elimination from weak breathing responses*)
- Respiratory acidosis (*Related to impaired elimination*)

- Tuberculosis (pulmonary)
(Related to impaired elimination from weak breathing responses)

Decreased in:

Interpretation requires clinical information and evaluation of other electrolytes

- Acute renal failure (*Response to buildup of ketoacids*)
- Anxiety (*Related to hyperventilation; too much CO₂ is exhaled*)
- Dehydration (*Response to metabolic acidosis that develops*)
- Diabetic ketoacidosis (*Response to buildup of ketoacids*)
- Diarrhea (severe) (*Acidosis related to loss of base ions like HCO₃⁻; most of CO₂ content is in this form*)
- High fever (*Response to neutralize acidosis present during fever*)
- Metabolic acidosis (*Response to neutralize acidosis*)
- Respiratory alkalosis (*Hyperventilation; too much CO₂ is exhaled*)
- Salicylate intoxication (*Response to neutralize-related metabolic acidosis*)
- Starvation (*Used to neutralize buildup of ketoacids*)

CRITICAL VALUES:

Less than 15 mmol/L

Greater than 40 mmol/L

Observe the patient for signs and symptoms of excessive or insufficient CO₂ levels, and report these findings to the health care provider (HCP). If the patient has been vomiting for several days and is breathing shallowly, or if the patient has had gastric suctioning and is breathing shallowly, this may indicate elevated CO₂ levels. Decreased CO₂ levels are evidenced by deep, vigorous breathing and flushed skin.

INTERFERING FACTORS:

- Drugs that may cause an increase in tCO₂ levels include acetylsalicylic acid, aldosterone, bicarbonate, carbenicillin, carbenoxolone, corticosteroids, dexamethasone, ethacrinic acid, laxatives (chronic abuse), and x-ray contrast agents.
- Drugs that may cause a decrease in tCO₂ levels include acetazolamide, acetylsalicylic acid (initially), amiloride, ammonium chloride, fluorides, metformin, methicillin, nitrofurantoin, NSD 3004 (long-acting carbonic anhydrase inhibitor), paraldehyde, tetracycline, triamterene, and xylitol.
- Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results. The specimen should be stored under anaerobic conditions after collection to prevent the diffusion of CO₂ gas from the specimen. Falsely decreased values result from uncovered specimens. It is estimated that CO₂ diffuses from the sample at the rate of 6 mmol/hr.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Inform the patient that the test is used to assess the effect of total carbon dioxide levels on respiratory and metabolic acid-base balance.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's genitourinary and respiratory systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Abnormal CO₂ values may be associated with diseases of the respiratory system. Malnutrition is commonly seen in patients with severe respiratory

disease for reasons including fatigue, lack of appetite, and gastrointestinal distress. Research has estimated that the daily caloric intake required for respiration of patients with chronic obstructive pulmonary disease is 10 times higher than that of normal individuals. Adequate intake of vitamins A and C is also important to prevent pulmonary infection and to decrease the extent of lung tissue damage. The importance of following the prescribed diet should be stressed to the patient and/or caregiver.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include anion gap, arterial/alveolar oxygen ratio, biopsy lung, blood gases, chest x-ray, chloride, cold agglutinin titer, culture bacterial blood, culture bacterial sputum, culture mycobacterium, culture viral, cytology sputum, eosinophil count, ESR, gallium scan, gram stain, IgE, ketones, lung perfusion scan, osmolality, phosphorus, plethysmography, pleural fluid analysis, potassium, PFT, pulse oximetry, salicylate, and white blood cell count and differential.
- ▶ Refer to the Cardiovascular, Genitourinary, and Respiratory System tables at the end of the book for related tests by body system.

Carboxyhemoglobin

SYNONYM/ACRONYM: Carbon monoxide, CO, COHb, COH.

SPECIMEN: Whole blood (1 mL) collected in a green-top (heparin) or lavender-top (EDTA) tube, depending on laboratory requirement. Specimen should be transported tightly capped (anaerobic) and in an ice slurry if blood gases are to be performed simultaneously. Carboxyhemoglobin is stable at room temperature.

REFERENCE VALUE: (Method: Spectrophotometry, co-oximetry)

	% Saturation of Hemoglobin
Newborns	10–12%
Nonsmokers	Up to 2%
Smokers	Up to 10%

DESCRIPTION: Exogenous carbon monoxide (CO) is a colorless, odorless, tasteless by-product of incomplete combustion derived from the exhaust of automobiles, coal and gas burning, and tobacco smoke. Endogenous CO is produced as a result of red blood cell catabolism. CO levels are elevated in newborns as a result of the combined effects of high hemoglobin turnover and the inefficiency of the infant's respiratory system. CO binds tightly to hemoglobin with an affinity 250 times greater than oxygen, competitively and dramatically reducing the oxygen-carrying capacity of hemoglobin. The increased percentage of bound CO reflects the extent to which normal transport of oxygen has been negatively affected. Overexposure causes hypoxia, which results in headache,

nausea, vomiting, vertigo, collapse, or convulsions. Toxic exposure causes anoxia, increased levels of lactic acid, and irreversible tissue damage, which can result in coma or death. Acute exposure may be evidenced by a cherry red color to the lips, skin, and nail beds; this observation may not be apparent in cases of chronic exposure. A direct correlation has been implicated between carboxyhemoglobin levels and symptoms of atherosclerotic disease, angina, and myocardial infarction.

INDICATIONS:

- Assist in the diagnosis of suspected CO poisoning
- Evaluate the effect of smoking on the patient
- Evaluate exposure to fires and smoke inhalation

RESULT:

Increased in:

- CO poisoning
- Hemolytic disease (*CO released during red blood cell catabolism*)
- Tobacco smoking

Decreased in: N/A

CRITICAL VALUES: 

Percent of total hemoglobin	Symptoms
10%–20%	Asymptomatic
10%–30%	Disturbance of judgment, headache, dizziness
30%–40%	Dizziness, muscle weakness, vision problems, confusion, increased heart rate, increased breathing rate
50%–60%	Loss of consciousness, coma
Greater than 60%	Death

C

Women and children may suffer more severe symptoms of carbon monoxide poisoning at lower levels of carbon monoxide than men because women and children usually have lower red blood cell counts.

A possible intervention in moderate CO poisoning is the administration of supplemental oxygen given at atmospheric pressure. In severe CO poisoning, hyperbaric oxygen treatments may be used.

INTERFERING FACTORS:

- Specimen should be collected before administration of oxygen therapy.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to evaluate the extent of carbon monoxide poisoning and toxicity.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's respiratory system and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ◆ Note any recent procedures that can interfere with test results.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Explain to the patient or family members that the cause of the headache, vomiting, dizziness, convulsions, or coma could be related to CO exposure. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ If carboxyhemoglobin measurement will be performed simultaneously with arterial blood gases, prepare an ice slurry in a cup or plastic bag and have it on hand for immediate transport of the specimen to the laboratory.
- ◆ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Recognize anxiety related to test results, and be supportive of impaired activity related to fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications

of the test results, as appropriate. Educate the patient regarding access to counseling services. Educate the patient regarding avoiding gas heaters and indoor cooking fires without adequate ventilation, and the need to have gas furnaces checked yearly for CO leakage. Inform the patient of smoking cessation programs, as appropriate.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include angiography pulmonary, arterial/alveolar oxygen ratio, blood gases, carbon dioxide, complete blood count, lung perfusion scan, lung ventilation scan, plethysmography, and PFT.
- Refer to the Respiratory System table at the back of the book for related tests by body system.

Carcinoembryonic and Cancer Antigens

SYNONYM/ACRONYM: Carcinoembryonic antigen (CEA), Cancer antigen 125 (CA 125), Cancer antigen 15-3 (CA 15-3), Cancer antigen 19-9 (CA 19-9), Cancer antigen 27.29 (CA 27.29).

SPECIMEN: Serum (1 mL) collected in a red-top tube. Care must be taken to use the same assay method if serial measurements are to be taken.

REFERENCE VALUE: (Method: Radioactive immunoassay, Immunochemiluminometric assay [ICMA])

CEA

Smoking Status	Conventional Units	SI Units (Conventional Units × 1)
Smoker	Less than 5.0 ng/mL	Less than 5.0 mcg/L
Nonsmoker	Less than 2.5 ng/mL	Less than 2.5 mcg/L

CA 125

Conventional Units	SI Units (Conventional Units × 1)
Less than 35 units/mL	Less than 35 kU/L

CA 15-3

Conventional Units	SI Units (Conventional Units × 1)
Less than 30 units/mL	Less than 30 kU/L

CA 19-9

Conventional Units	SI Units (Conventional Units × 1)
Less than 35 units/mL	Less than 35 kU/L

CA 27.29

Conventional Units	SI Units (Conventional Units × 1)
Less than 37.7 units/mL	Less than 37.7 kU/L

DESCRIPTION: Carcinoembryonic antigen (CEA) is a glycoprotein normally produced only during early fetal life and rapid multiplication of epithelial cells, especially those of the digestive system. CEA also appears in the blood of chronic smokers. Although the test is not diagnostic for any specific disease and is not useful as a screening test for cancer, it is very useful for monitoring response to therapy in breast, liver, colon, and gastrointestinal cancer. Serial monitoring is also a useful indicator of recurrence or metastasis in colon or liver carcinoma.

CA 125, a glycoprotein present in normal endometrial tissue, appears in the blood when natural endometrial protective barriers are destroyed, as occurs in cancer or endometriosis. Persistently rising levels indicate a poor prognosis, but absence of the tumor marker does not rule out tumor presence. Levels may also rise in pancreatic, liver, colon, breast, and lung cancers. CA 125 is most useful in monitoring the progression or recurrence of known ovarian cancer. It is not useful as a screening test when used alone.

CA 15-3 monitors patients for recurrence or metastasis of breast carcinoma.

CA 19-9 is a carbohydrate antigen used for post-therapeutic monitoring of patients with gastrointestinal, pancreatic, liver, and colorectal cancer.

CA 27.29 is a glycoprotein product of the muc-1 gene. It is most useful as a serial monitor for response to therapy or recurrence of breast carcinoma.

INDICATIONS:

CEA

- Determine stage of colorectal cancer and test for recurrence or metastasis
- Monitor response to treatment of breast and gastrointestinal cancers

CA 125

- Assist in the diagnosis of carcinoma of the cervix and endometrium
- Assist in the diagnosis of ovarian cancer
- Monitor response to treatment of ovarian cancer

CA 15-3 and CA 27.29

- Monitor recurrent carcinoma of the breast

CA 19-9

- Monitor effectiveness of therapy
- Monitor gastrointestinal, head and neck, and gynecological carcinomas
- Predict recurrence of cholangiocarcinoma
- Predict recurrence of stomach, pancreatic, colorectal, gallbladder, liver, and urothelial carcinomas

RESULT:

Increased in:

CEA

- Benign tumors, including benign breast disease

- Chronic tobacco smoking
- Cirrhosis
- Colorectal, pulmonary, gastric, pancreatic, breast, head or neck, esophageal, ovarian, or prostate cancer
- Inflammatory bowel disease
- Pancreatitis
- Radiation therapy (transient)

CA 125

- Breast, colon, endometrial, liver, lung, ovarian, and pancreatic cancer
- Endometriosis
- First-trimester pregnancy
- Menses
- Ovarian abscess
- Pelvic inflammatory disease
- Peritonitis

CA 15-3 and CA 27.29

- Recurrence of breast carcinoma

CA 19-9

- Gastrointestinal, head and neck, and gynecologic carcinomas
- Recurrence of stomach, pancreatic, colorectal, gallbladder, liver, and urothelial carcinomas
- Recurrence of cholangiocarcinoma

Decreased in:

- Effective therapy or removal of the tumor

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to monitor the progress of various types of cancer and evaluate the response to therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal, immune, and reproductive systems, as well as results of previously performed laboratory tests, diagnostic, and surgical procedures.
- ▶ Note any recent radiology procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Determine if the patient smokes, because smokers may have false elevations of CEA.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 minutes. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss them with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Cancer Association (www.cancer.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that the test may be repeated periodically to monitor response to therapy. Instruct the patient in the importance of continuing scheduled therapy or follow-up visits. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include barium enema, biopsy breast, biopsy cervical, biopsy intestinal, biopsy liver, capsule endoscopy, colonoscopy, colposcopy, fecal analysis, HCG, liver & spleen scan, MRI breast, MRI liver, mammogram, stereotactic breast biopsy, proctosigmoidoscopy, radiofrequency ablation liver, US breast, and US liver.
- ▶ Refer to the Gastrointestinal, Immune, and Reproductive System tables at the back of the book for related tests by body system.



Catecholamines, Blood and Urine

SYNONYM/ACRONYM: Epinephrine, norepinephrine, dopamine.

SPECIMEN: Plasma (2 mL) collected in green-top (heparin) tube. Urine (25 mL) from a timed specimen collected in a clean, plastic, amber collection container with 6N hydrochloric acid as a preservative.

REFERENCE VALUE: (Method: High-performance liquid chromatography)

Blood	Conventional Units	SI Units
		<i>(Conventional Units × 5.46)</i>
Epinephrine		
<i>Supine, 30 min</i>	0–110 pg/mL	0–600 pmol/L
<i>Standing, 30 min</i>	0–140 pg/mL	0–764 pmol/L
		<i>(Conventional Units × 5.91)</i>
Norepinephrine		
<i>Supine, 30 min</i>	70–750 pg/mL	414–4432 pmol/L
<i>Standing, 30 min</i>	200–1700 pg/mL	1182–10,047 pmol/L
		<i>(Conventional Units × 6.53)</i>
Dopamine		
<i>Supine or standing</i>	0–30 pg/mL	0–196 pmol/L

Urine	Conventional Units	SI Units
		<i>(Conventional Units × 5.46)</i>
Epinephrine		
<i>1–4 yr</i>	0–6.0 mcg/24 h	0–32.8 nmol/24 h
<i>4–10 yr</i>	0–10.0 mcg/24 h	0–54.6 nmol/24 h
<i>10 yr–Adult</i>	0.5–20 mcg/24 h	2.7–109 nmol/24 h
		<i>(Conventional Units × 5.91)</i>
Norepinephrine		
<i>1–4 yr</i>	0–29 mcg/24 h	0–171 nmol/24 h
<i>4–10 yr</i>	8–65 mcg/24 h	47–384 nmol/24 h
<i>10 yr–adult</i>	15–80 mcg/24 h	89–473 nmol/24 h
		<i>(Conventional Units × 6.53)</i>
Dopamine		
<i>1–4 yr</i>	10–260 mcg/24 h	65–1698 nmol/24 h
<i>4 yr–adult</i>	65–400 mcg/24 h	424–2612 nmol/24 h

DESCRIPTION: Catecholamines are produced by the chromaffin tissue of the adrenal medulla. They also are found in sympathetic nerve endings and in the brain. The major catecholamines are epinephrine, norepinephrine, and dopamine. They prepare the body for the fight-or-flight stress response, help regulate metabolism, and are excreted from the body by the kidneys. Levels are affected by diurnal variations, fluctuating in response to stress, postural changes, diet, smoking, drugs, and temperature changes. As a result, blood measurement is not as reliable as a 24-hr timed urine test. For test results to be valid, all of the previously mentioned environmental variables must be controlled when the test is performed. Results of blood specimens are most reliable when the specimen is collected during a hypertensive episode. Catecholamines are measured when there is high suspicion of pheochromocytoma but urine results are normal or borderline. Use of a clonidine suppression test with measurement of plasma catecholamines may be requested. Failure to suppress production of catecholamines after administration of clonidine supports the diagnosis of pheochromocytoma. Elevated homovanillic acid levels rule out pheochromocytoma because this tumor primarily secretes epinephrine. Elevated catecholamines without hypertension suggest neuroblastoma or ganglioneuroma. Findings should be compared with metanephrines and vanillylmandelic acid, which are the metabolites of epinephrine and norepinephrine. Findings

should also be compared with homovanillic acid, which is the product of dopamine metabolism.

INDICATIONS:

- Assist in the diagnosis of neuroblastoma, ganglioneuroma, or dysautonomia
- Assist in the diagnosis of pheochromocytoma
- Evaluate acute hypertensive episode
- Evaluate hypertension of unknown origin
- Screen for pheochromocytoma among family members with an autosomal dominant inheritance pattern for Lindau-von Hippel disease or multiple endocrine neoplasia

RESULT:

Increased in:

- Diabetic acidosis (epinephrine and norepinephrine)
- Ganglioblastoma (epinephrine, slight increase; norepinephrine, large increase)
- Ganglioneuroma (all are increased; norepinephrine, largest increase)
- Hypothyroidism (epinephrine and norepinephrine)
- Long-term manic-depressive disorders (epinephrine and norepinephrine)
- Myocardial infarction (epinephrine and norepinephrine)
- Neuroblastoma (all are increased; norepinephrine and dopamine, largest increase)
- Pheochromocytoma (epinephrine, continuous or intermittent increase; norepinephrine, slight increase)
- Shock (epinephrine and norepinephrine)
- Strenuous exercise (epinephrine and norepinephrine)

Decreased in:

- Autonomic nervous system dysfunction (norepinephrine)
- Orthostatic hypotension (norepinephrine)
- Parkinson's disease (dopamine)

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase plasma catecholamine levels include ajmaline, chlorpromazine, cyclopropane, diazoxide, ether, monoamine oxidase inhibitors, nitroglycerin, pentazocine, perphenazine, phenothiazine, promethazine, and theophylline.
- Drugs that may decrease plasma catecholamine levels include clonidine, metyrosine, and reserpine.
- Drugs that may increase urine catecholamine levels include acetaminophen, atenolol, dopamine (intravenous), isoproterenol, methyl dopa, niacin, nitroglycerin, prochlorperazine, rauwolfia, reserpine, syrosin-gopine, and theophylline.
- Drugs that may decrease urine catecholamine levels include bretylium tosylate, clonidine, decaborane, guanethidine, guanfacine, methyl dopa, ouabain, radiographic substances, and reserpine.
- Stress, hypoglycemia, smoking, and drugs can produce elevated catecholamines.
- Secretion of catecholamines exhibits diurnal variation, with the lowest levels occurring at night.
- Secretion of catecholamines varies during the menstrual cycle, with higher levels excreted during the luteal phase and lowest levels during ovulation.
- Diets high in amines (e.g., bananas, avocados, beer, aged cheese, chocolate, cocoa, coffee, fava beans, grains, tea, vanilla,

walnuts, Chianti wine) can produce elevated catecholamine levels.

- Failure to collect all urine and store 24-hr specimen properly will yield a falsely low result.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the blood test is used to diagnose catecholamine-secreting tumors and in the investigation of hypertension; the urine test is used to diagnose pheochromocytoma and in the work-up of neuroblastoma.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine system, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Record the date of the patient's last menstrual period.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient.

Blood

- ♦ Inform the patient that he or she may be asked to keep warm and to rest for 45 to 60 min before the test. Inform the patient that multiple specimens may be required. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

Inform the patient that a saline lock may be inserted before the test because the stress of repeated venipunctures may increase catecholamine levels.

Urine

- Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain related to the procedure. Explain to the patient that there should be no discomfort during the procedure. Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine over a 24-hr period must be saved; if a preservative has been added to the container, instruct the patient not to discard the preservative. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom as a reminder to save all urine. Instruct the patient to void all urine into the collection device, then pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.

Blood and Urine

- Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- Instruct the patient to follow a normal-sodium diet for 3 days before testing, abstain from smoking tobacco for 24 hr before testing, and avoid consumption of foods high in amines for 48 hr before testing.
- Instruct the patient to avoid self-prescribed medications for 2 wk before testing (especially appetite suppressants and cold and allergy medications, such as nose drops, cough suppressants, and bronchodilators).

- Instruct the patient to withhold prescribed medication (especially methyl dopa, epinephrine, levodopa, and methenamine mandelate) if directed by the health care provider (HCP).
- Instruct the patient to withhold food and fluids for 10 to 12 hr before the test. Protocols may vary from facility to facility.
- Instruct the patient collecting a 24-hr urine specimen to avoid excessive stress and exercise during the test collection period.
- Prior to blood specimen collection, prepare an ice slurry in a cup or plastic bag to have ready for immediate transport of the specimen to the laboratory. Prechill the collection tube in the ice slurry.

INTRATEST:

- Ensure that the patient has complied with dietary, medication, and activity restrictions and with pretesting preparations; assure that food and fluids have been restricted for at least 10 to 12 hr prior to the procedure, and that excessive exercise and stress have been avoided prior to the procedure. Instruct the patient to continue to avoid excessive exercise and stress during the 24-hr collection of urine.
- If the patient has a history of allergic reaction to latex, care should be taken to avoid the use of equipment containing latex.
- Instruct the patient to cooperate fully and to follow directions.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date, and time of collection.

Blood

- Perform a venipuncture between 6 and 8 a.m.; collect the specimen in a prechilled tube.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Ask the patient to stand for 10 min, and then perform a second venipuncture and obtain a sample as previously described.
- ▶ Each sample should be placed in an ice slurry immediately after collection. Information on the specimen labels should be protected from water in the ice slurry by first placing the specimens in a protective plastic bag. Promptly transport the specimens to the laboratory for processing and analysis.

Urine

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.

Blood and Urine

- ▶ Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that can affect test results.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography adrenal, calcitonin, CT renal, HVA, metanephrines, renin, and VMA.
- ▶ Refer to the Endocrine System table at the end of the book for related tests by body system.

CD4/CD8 Enumeration

SYNONYM/ACRONYM: T-cell profile.

SPECIMEN: Whole blood (1 mL) collected in green-top (heparin) tube.

REFERENCE VALUE: (Method: flow cytometry)

Total lymphocytes	1000–4800/mm ³ (1.0–4.8 × 10 ³)	34%
Mature T Cells (CD3)	650–3036/mm ³	65–92%
Helper T Cells (CD4)	310–2112/mm ³	31–64%
Suppressor T Cells (CD8)	80–1353/mm ³	8–41%
CD4/CD8 ratio	1.0–3.7	

DESCRIPTION: Enumeration of lymphocytes, identification of cell lineage, and identification of cellular stage of development are used to diagnose and classify malignant myeloproliferative diseases and to plan treatment. T-cell enumeration is also useful in the evaluation and management of immunodeficiency and autoimmune disease. A severely depressed CD4 count is an excellent predictor of imminent opportunistic infection. HIV viral load is another important test used to establish a baseline for viral activity when a person is first diagnosed with HIV. Viral load testing is performed on plasma from a whole blood sample collected in EDTA. Methods commonly used to perform viral load testing include branched DNA (bDNA) or reverse transcriptase PCR (RT-PCR). Results are not interchangeable from method to method. Therefore, it is important to use the same viral load method for serial testing. Baseline and repeat testing for CD4 count and viral load are

usually performed 2 to 4 wk apart. The viral load demonstrates how actively the virus is reproducing and helps determine whether treatment is necessary. CD4 count is a reflection of immune status. Public health guidelines recommend that treatment of asymptomatic patients be considered when CD4 count is greater than 350/mm³ and viral load is 55,000 copies/mL or greater (bDNA) or 30,000 copies/mL or greater (RT-PCR); treatment is recommended when the patient is symptomatic regardless of test results or when the patient is asymptomatic and CD4 count is less than 350/mm³ and viral load is detectable. If retroviral therapy is initiated, CD4 counts and viral load studies will be monitored every 3 to 4 mo. Viral mutations occur; increased viral load may indicate resistance to antiviral drugs. Changes in drug therapy may warrant additional viral load studies to verify efficacy of modified therapy.

INDICATIONS:

- Assist in the diagnosis of AIDS and plan treatment
- Evaluate malignant myeloproliferative diseases and plan treatment
- Evaluate thymus-dependent or cellular immunocompetence

RESULT:**Increased in:**

- Malignant myeloproliferative diseases (e.g., acute and chronic lymphocytic leukemia, lymphoma)

Decreased in:

- AIDS
- Aplastic anemia
- Hodgkin's disease

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase T-cell count include interferon- γ .
- Drugs that may decrease T-cell count include chlorpromazine and prednisone.
- Specimens should be stored at room temperature.
- Recent radioactive scans or radiation can decrease T-cell counts.
- Values may be abnormal in patients with severe recurrent illness or after recent surgery requiring general anesthesia.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to monitor disease progression and effectiveness of retroviral therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known

allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's hematopoietic and immune systems and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** As appropriate, stress the importance of good nutrition and suggest that the patient

meet with a nutritional specialist.

Stress the importance of following the care plan for medications and follow-up visits. Inform the patient that subsequent requests for follow-up blood work at regular intervals should be anticipated.

- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient as to the risk of infection related to immunosuppressed inflammatory response and fatigue related to decreased energy production. Educate the patient regarding access to counseling services.
- ▶ **Sensitivity to social and cultural issues.** Counsel the patient, as appropriate, regarding risk of transmission and proper prophylaxis, and reinforce the importance of strict adherence to the treatment regimen, including consultation with a pharmacist.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, bronchoscopy, complete blood count, culture and smear mycobacteria, culture viral, cytology sputum, gallium scan, HIV-1/HIV-2 antibodies, laparoscopy abdominal, LAP, lymphangiogram, MRI musculoskeletal, mediastinoscopy, β_2 -microglobulin, platelet count, and WBC count and differential.
- ▶ Refer to the Hematopoietic and Immune System tables at the end of the book for related tests by body system.

Cerebrospinal Fluid Analysis

SYNONYM/ACRONYM: CSF analysis.

SPECIMEN: CSF (1 to 3 mL) collected in three or four separate plastic conical tubes. Tube 1 is used for chemistry and serology testing, tube 2 is used for microbiology, tube 3 is used for cell count, and tube 4 is used for miscellaneous testing.

REFERENCE VALUE: (Method: Macroscopic evaluation of appearance; spectrophotometry for glucose, lactic acid, and protein; radioimmunoassay for myelin basic protein; nephelometry for immunoglobulin G [IgG]; electrophoresis for oligoclonal banding; Gram stain, India ink preparation, and culture for microbiology; microscopic examination of fluid for cell count; flocculation for Venereal Disease Research Laboratory [VDRL])

Lumbar Puncture	Conventional Units	SI Units
Color and appearance	Crystal clear	
Protein	15–45 mg/dL	(Conventional Units $\times 10$) 150–450 mg/L
Glucose		(Conventional Units $\times 0.0555$)
<i>Infant or child</i>	60–80 mg/dL	3.3–4.4 mmol/L
<i>Adult</i>	40–70 mg/dL	2.2–3.9 mmol/L
Lactic acid		(Conventional Units $\times 0.111$)
<i>Neonate</i>	10–60 mg/dL	1.1–6.7 mmol/L
<i>3–10 d</i>	10–40 mg/dL	1.1–4.4 mmol/L
<i>Adult</i>	Less than 25.2 mg/dL	Less than 2.8 mmol/L
Myelin basic protein	Less than 4.0 ng/mL	(Conventional Units $\times 1$) Less than 4.0 mcg/L
Oligoclonal bands	Absent	(Conventional Units $\times 10$)
IgG	Less than 3.4 mg/dL	Less than 34 mg/L
Gram stain	Negative	
India ink	Negative	
Culture	No growth	
RBC count	0	0
WBC count		(Conventional Units $\times 1$)
<i>Neonate–1 mo</i>	0–30/mL	0–30 $\times 10^6$ /L
<i>1 mo–1 yr</i>	0–10/mL	0–10 $\times 10^6$ /L
<i>1–5 yr</i>	0–8/mL	0–8 $\times 10^6$ /L
<i>5 yr–Adult</i>	0–5/mL	0–5 $\times 10^6$ /L

WBC Differential	Adult	Children
<i>Lymphocytes</i>	40%–80%	5%–13%
<i>Monocytes</i>	15%–45%	50%–90%
<i>Neutrophils</i>	0%–6%	0%–8%
VDRL	Nonreactive	
Cytology	No abnormal cells seen	

RBC = red blood cell; VDRL = Venereal Disease Research Laboratory; WBC = white blood cell. Color should be assessed after sample is centrifuged.

DESCRIPTION: Cerebrospinal fluid (CSF) circulates in the subarachnoid space and has a twofold function: to protect the brain and spinal cord from injury

and to transport products of cellular metabolism and neurosecretion. The total volume of CSF is 90 to 150 mL in adults and 60 mL in infants. CSF

analysis helps determine the presence and cause of bleeding and assists in diagnosing cancer, infections, and degenerative and autoimmune diseases of the brain and spinal cord. Specimens for analysis are most frequently obtained by lumbar puncture and sometimes by ventricular or cisternal puncture. Lumbar puncture can also have therapeutic uses, including injection of drugs and anesthesia.

INDICATIONS:

- Assist in the diagnosis and differentiation of subarachnoid or intracranial hemorrhage
- Assist in the diagnosis and differentiation of viral or bacterial meningitis or encephalitis
- Assist in the diagnosis of diseases such as multiple sclerosis, autoimmune disorders, or degenerative brain disease
- Assist in the diagnosis of neurosyphilis and chronic central nervous system (CNS) infections
- Detect obstruction of CSF circulation due to hemorrhage, tumor, or edema
- Establish the presence of any condition decreasing the flow of oxygen to the brain
- Monitor for metastases of cancer into the CNS
- Monitor severe brain injuries

RESULT:

Increased in:

- Color and appearance (*xanthochromia is any pink, yellow, or orange color*): **bloody—hemorrhage; xanthochromic—old hemorrhage, red blood cell (RBC) breakdown, methemoglobin, bilirubin (greater than 6 mg/dL), increased protein (greater than**

150 mg/dL), melanin (meningeal melanosaarcoma), carotene (systemic carotenemia); bazy—meningitis; pink to dark yellow—aspiration of epidural fat; turbid—cells, microorganisms, protein, fat, or contrast medium

- Protein (*Related to alterations in blood brain barrier that allow permeability to proteins*): meningitis, encephalitis
- Lactic acid (*Related to cerebral hypoxia and correlating anaerobic metabolism*): bacterial, tubercular, fungal meningitis
- Myelin basic protein (*Related to accumulation as a result of nerve sheath demyelination*): trauma, stroke, tumor, multiple sclerosis, subacute sclerosing panencephalitis
- IgG and oligoclonal banding (*Related to autoimmune or inflammatory response*): multiple sclerosis, CNS syphilis, and subacute sclerosing panencephalitis
- Gram stain: **meningitis due to Escherichia coli, Streptococcus agalactiae, Streptococcus pneumoniae, Haemophilus influenzae, Mycobacterium avium-intracellulare, Mycobacterium leprae, Mycobacterium tuberculosis, Neisseria meningitidis, Cryptococcus neoformans**
- India ink preparation: **meningitis due to C. neoformans**
- Culture: **encephalitis or meningitis due to herpes simplex virus, S. pneumoniae, H. influenzae, N. meningitidis, C. neoformans**
- RBC count: **hemorrhage**
- White blood cell (WBC) count: **General increase—***injection of contrast media or anticancer drugs in subarachnoid space; CSF infarct; metastatic tumor in contact with CSF; reaction to repeated lumbar puncture*

Elevated WBC count with a predominance of neutrophils indicative of bacterial meningitis

Elevated WBC count with a predominance of lymphocytes indicative of viral, tubercular, parasitic, or fungal meningitis; multiple sclerosis

Elevated WBC count with a predominance of monocytes indicative of chronic bacterial meningitis, amebic meningitis, multiple sclerosis, toxoplasmosis

Increased plasma cells indicative of acute viral infections, multiple sclerosis, sarcoidosis, syphilitic meningoencephalitis, subacute sclerosing panencephalitis, tubercular meningitis, parasitic infections, Guillain-Barré syndrome

Presence of eosinophils indicative of parasitic and fungal infections, acute polyneuritis, idiopathic hypereosinophilic syndrome, reaction to drugs or a shunt in CSF

- VDRL: *syphilis*

Positive findings in:

- Cytology: *malignant cells*

Decreased in:


- Glucose: *bacterial and tubercular meningitis*



CRITICAL VALUES:

- Positive Gram stain, India ink preparation, or culture
- Presence of malignant cells or blasts
- Elevated WBC count
- Glucose greater than 37 mg/dL. Note and immediately report to the health care provider (HCP) any positive or critically increased results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

-  This procedure is contraindicated if infection is present at the needle insertion site.

-  It may also be contraindicated in patients with degenerative joint disease or coagulation defects and in patients who are uncooperative during the procedure.
-  Use with extreme caution in patients with increased intracranial pressure because overly rapid removal of CSF can result in herniation.

Other considerations:

- Drugs that may decrease CSF protein levels include cefotaxime and dexamethasone.
- Interferon- β may increase myelin basic protein levels.
- Drugs that may increase CSF glucose levels include cefotaxime and dexamethasone.
- RBC count may be falsely elevated with a traumatic spinal tap.
- Delays in analysis may present a false positive appearance of xanthochromia due to RBC lysis that begins within 4 hr of a bloody tap.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to assist in the differential diagnosis of infection or hemorrhaging in the brain. It is also used in the evaluation of other conditions with significant neuromuscular effects.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.
- ▶ Obtain a history of the patient's immune and musculoskeletal systems and results of previously performed

laboratory tests and diagnostic and surgical procedures.

- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that the position required may be awkward, but that someone will assist during the procedure. Stress the importance of remaining still and breathing normally throughout the procedure. Inform the patient that specimen collection takes approximately 20 min. Address concerns about pain and explain that a stinging sensation may be felt when the local anesthetic is injected. Instruct the patient to report any pain or other sensations that may require repositioning the spinal needle. Explain that there may be some discomfort during the procedure. Inform the patient the procedure will be performed by a HCP.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependant on the type of anticoagulant. Notify HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Collect the specimen in four plastic conical tubes.
- ▶ Record baseline vital signs.
- ▶ To perform a lumbar puncture, position the patient in the knee-chest position at the side of the bed. Provide pillows to support the spine or for the patient to grasp. The sitting position is an alternative. In this position, the patient must bend the neck and chest to the knees.
- ▶ Prepare the site—usually between L3 and L4, or between L4 and L5—with povidone-iodine and drape the area.
- ▶ A local anesthetic is injected. Using sterile technique, the HCP inserts the spinal needle through the spinous processes of the vertebrae and into the subarachnoid space. The stylet is removed. If the needle is properly placed, CSF drips from the needle.
- ▶ Attach the stopcock and manometer, and measure initial pressure. Normal pressure for an adult in the lateral recumbent position is 90 to 180 mm H₂O; normal pressure for a child age 8 years or younger is 10 to 100 mm H₂O. These values depend on the body position and are different in a horizontal or sitting position.
- ▶ CSF pressure may be elevated if the patient is anxious, holding his or her breath, or tensing muscles. It may also be elevated if the patient's knees are flexed too firmly against the abdomen. CSF pressure may be significantly elevated in patients with intracranial tumors. If the initial pressure is elevated, the HCP may perform Queckenstedt's test. To perform this test, pressure is applied to the jugular vein for about 10 sec. CSF pressure usually rises rapidly in response to the occlusion, and then returns to the pretest level within 10 sec after the pressure is released. Sluggish response may indicate CSF obstruction.

- ▶ Obtain four vials of spinal fluid in separate tubes (1 to 3 mL in each), and label them numerically (1–4 or 5) in the order they were filled.
- ▶ A final pressure reading is taken, and the needle is removed. Clean the puncture site with an antiseptic solution and apply direct pressure with dry gauze to stop bleeding or CSF leakage. Observe puncture site for bleeding, CSF leakage, or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Monitor vital signs and neurologic status and for headache every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If permitted, administer fluids to replace lost CSF and help prevent or relieve headache—a side effect of lumbar puncture.
- ▶ Position the patient flat in the supine position with head of bed at not more than a 30° elevation, following the HCP's instructions. Maintain position for 8 hr. Changing position is acceptable as long as the body remains horizontal.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's

lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Provide information regarding vaccine-preventable diseases when indicated (encephalitis, influenza, meningococcal diseases). Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count, CT brain, culture for appropriate organisms (blood, fungal, mycobacteria, sputum, throat, viral, wound), EMG, evoked brain potentials, gram stain, MRI brain, PET brain, and syphilis serology.
- ▶ Refer to the Immune and Musculoskeletal System tables at the end of the book for related tests by body system.

Ceruloplasmin

SYNONYM/ACRONYM: Copper oxidase, Cp.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Nephelometry)

Age	Conventional Units	SI Units (Conventional Units × 10)
Newborn–3 mo	5–18 mg/dL	50–180 mg/L
6–12 mo	33–43 mg/dL	330–430 mg/L
1–3 yr	26–55 mg/dL	260–550 mg/L
4–5 yr	27–56 mg/dL	270–560 mg/L
6–7 yr	24–48 mg/dL	240–480 mg/L
Greater than 7 yr	20–54 mg/dL	200–540 mg/L

DESCRIPTION: Ceruloplasmin is an α_2 -globulin produced by the liver that binds copper for transport in the blood after it is absorbed from the gastrointestinal system. Decreased production of this globulin causes copper to be deposited in body tissues such as the brain, liver, corneas, and kidneys.

INDICATIONS:

- Assist in the diagnosis of Menkes (kinky hair) disease
- Assist in the diagnosis of Wilson's disease
- Determine genetic predisposition to Wilson's disease
- Monitor patient response to total parenteral nutrition (hyperalimentation)

RESULT:

Increased in:

Ceruloplasmin is an acute phase reactant protein and will be increased in many inflammatory conditions including cancer.

- Acute infections
- Biliary cirrhosis
- Cancer of the bone, lung, stomach
- Copper intoxication
- Hodgkin's disease
- Leukemia
- Pregnancy (last trimester)

(Estrogen increases copper levels)

- Rheumatoid arthritis
- Tissue necrosis

Decreased in:

- Menkes disease (**Severe X-linked defect causing failed transport to the liver and tissues**)
- Nutritional deficiency of copper
- Wilson's disease (**Genetic defect causing failed transport to the liver and tissues**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase ceruloplasmin levels include anticonvulsants, norethindrone, oral contraceptives, and tamoxifen.
- Drugs that may decrease ceruloplasmin levels include asparaginase and levonorgestrel (Norplant).
- Excessive therapeutic intake of zinc may interfere with intestinal absorption of copper.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used in the evaluation of copper intoxication and liver disease, especially Wilson's disease.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary system and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Instruct the patient with copper deficiency to increase intake of foods rich in copper, as appropriate. Organ meats, shellfish, nuts, and legumes are good sources of dietary copper. High intake of zinc, iron, calcium, and manganese interferes with copper absorption. Copper deficiency does not normally occur in adults; however, patients receiving long-term total parenteral nutrition should be evaluated if signs and symptoms of copper deficiency appear, such as jaundice or eye color changes. Kayser-Fleischer rings (green-gold rings) in the cornea and a liver biopsy specimen showing more than 250 mcg of copper per gram confirms Wilson's disease.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.0

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy liver, copper, and zinc.
- ▶ Refer to the Hepatobiliary System table at the end of the book for related tests by body system.

Chest X-Ray

SYNONYM/ACRONYM: Chest radiography, CXR.

AREA OF APPLICATION: Lungs.

CONTRAST: None.

DESCRIPTION: Chest radiography, commonly called chest x-ray, is one of the most frequently performed radiological diagnostic studies. This study yields information about the pulmonary, cardiac, and skeletal systems. The lungs, filled with air, are easily penetrated by x-rays and appear black on chest images. A routine chest x-ray includes a posteroanterior (PA) projection, in which x-rays pass from the posterior to the anterior, and a left lateral projection. Additional projections that may be requested are obliques, lateral decubitus, or lordotic views. Portable x-rays, done in acute or critical situations, can be done at the bedside and usually include only the anteroposterior (AP) projection with additional images taken in a lateral decubitus position if the presence of free pleural fluid or air is in question. Chest images should be taken on full inspiration and erect when possible to minimize heart magnification and demonstrate fluid levels. Expiration images may be added to detect a pneumothorax or locate foreign bodies. Rib detail images may be taken to delineate bone pathology, useful when chest radiographs suggest fractures or metastatic lesions. Fluoroscopic studies of the chest can also be done to evaluate

lung and diaphragm movement. In the beginning of the disease process of tuberculosis, asthma, and chronic obstructive pulmonary disease, the results of a chest x-ray may not correlate with the clinical status of the patient and may even be normal.

INDICATIONS:

- Aid in the diagnosis of diaphragmatic hernia, lung tumors, intravenous devices, and metastasis
- Evaluate known or suspected pulmonary disorders, chest trauma, cardiovascular disorders, and skeletal disorders
- Evaluate placement and position of an endotracheal tube, tracheostomy tube, nasogastric feeding tube, pacemaker wires, central venous catheters, Swan-Ganz catheters, chest tubes, and intra-aortic balloon pump
- Evaluate positive PPD or Mantoux tests
- Monitor resolution, progression, or maintenance of disease
- Monitor effectiveness of the treatment regimen

RESULT:

Normal findings in:

- Normal lung fields, cardiac size, mediastinal structures, thoracic spine, ribs, and diaphragm

Abnormal findings in:

- Atelectasis
- Bronchitis
- Curvature of the spinal column (scoliosis)
- Enlarged heart
- Enlarged lymph nodes
- Flattened diaphragm
- Foreign bodies lodged in the pulmonary system
- Fractures of the sternum, ribs, and spine
- Lung pathology, including tumors
- Malposition of tubes or wires
- Mediastinal tumor and pathology
- Pericardial effusion
- Pericarditis
- Pleural effusion
- Pneumonia
- Pneumothorax
- Pulmonary bases, fibrosis, infiltrates
- Tuberculosis
- Vascular abnormalities

CRITICAL VALUES:

- Foreign body
- Malposition of tube, line, or post-op device (pacemaker)
- Pneumonia
- Pneumoperitoneum
- Pneumothorax
- Spine fracture

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair the results of the examination:

- Metallic objects within the examination field

- Improper adjustment of the radiographic equipment to accommodate obese or thin patients, which can cause overexposure or underexposure
- Incorrect positioning of the patient, which may produce poor visualization of the area to be examined
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the examination room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses cardiopulmonary status.
- ▶ Obtain a history of the patient's symptoms and complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's cardiovascular and respiratory system, symptoms, and results of

previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that no pain will be experienced during the test. Inform the patient that the procedure is performed in the radiology department or at the bedside by a registered radiological technologist, and takes approximately 5 to 15 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove all metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined.
- ▶ Patients are given a gown, robe, and foot coverings to wear.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the standing position facing the cassette or image detector, with hands on hips, neck extended, and shoulders rolled forward.

- ▶ Position the chest with the left side against the image holder for a lateral view.
- ▶ For portable examinations, elevate the head of the bed to the high Fowler's position.
- ▶ Ask the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.

POST-TEST:

- ▶ The report will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results and be supportive of impaired activity related to respiratory capacity and perceived loss of physical activity. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate and determine the need for a change in therapy or progression of the disease process. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy lung, blood gases, bronchoscopy, CT thoracic, complete blood count, culture mycobacteria, culture sputum, culture viral, electrocardiogram, gram stain, lung perfusion scan, MRI chest, pulmonary function study, pulse oximetry, and TB tests.
- ▶ Refer to the Cardiovascular and Respiratory System tables at the back of the book for related tests by body system.

Chlamydia Group Antibody

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect fluorescent antibody, polymerase chain reaction) Negative or less than fourfold increase in titer.

DESCRIPTION: *Chlamydia*, one of the most common sexually transmitted infections, is caused by *Chlamydia trachomatis*. These gram-negative bacteria are called *obligate cell parasites* because they require living cells for growth. There are three serotypes of *C. trachomatis*. One group causes lymphogranuloma venereum, with symptoms of the first phase of the disease appearing 2 to 6 wk after infection; another causes a genital tract infection different from lymphogranuloma venereum, in which symptoms in men appear 7 to 28 days after intercourse (women are generally asymptomatic); and the third causes the ocular disease trachoma (incubation period, 7 to 10 days). *Chlamydia psittaci* is the cause of psittacosis in birds and humans. It is increasing in prevalence as a pathogen responsible for other significant diseases of the respiratory system. The incubation period for *C. psittaci* infections in humans is 7 to 15 days, and is followed by chills, fever, and a persistent nonproductive cough.

Chlamydia is difficult to culture and grow, so antibody testing has become the technology of choice. The antigen used in many screening kits is not

species specific and can confirm only the presence of *Chlamydia* spp. Newer technology using DNA probes can identify the species. Assays that can specifically identify *C. trachomatis* require special collection and transport kits. They also have specific collection instructions, and the specimens are collected on swabs. The laboratory performing this testing should be consulted before specimen collection.

INDICATIONS:

- Establish *Chlamydia* as the cause of atypical pneumonia
- Establish the presence of chlamydial infection

RESULT:

Positive findings in:

- Chlamydial infection
- Infantile pneumonia (*Related to transmission at birth from an infected mother*)
- Infertility (*Related to scarring of ovaries or fallopian tubes from untreated chlamydia infection*)
- Lymphogranuloma venereum
- Ophthalmia neonatorum (*Related to transmission at birth from an infected mother*)
- Pelvic inflammatory disease
- Urethritis

CRITICAL VALUES: N/A**INTERFERING FACTORS:** N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of chlamydia infection.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and reproductive systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Inform the patient that several tests may be necessary to confirm diagnosis. Any individual positive result should be repeated in 7 to 10 days to monitor a change in titer.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Emphasize the need to return to have a convalescent blood sample taken in 7 to 14 days. Educate the patient regarding access to counseling services.
- ▶ **Social and cultural considerations:** Counsel the patient, as appropriate, as to the risk of sexual transmission and educate the patient regarding proper prophylaxis. Reinforce the importance of strict adherence to the treatment regimen.
- ▶ **Social and cultural considerations:** Inform the patient with positive *C. trachomatis* that findings must be reported to a local health department official, who will question the patient regarding his or her sexual partners.
- ▶ **Social and cultural considerations:** Offer support, as appropriate, to patients who may be the victim of rape or sexual assault. Educate the patient regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for a discussion during which you explain the risks of sexually transmitted diseases. It is also important to discuss emotions the patient may

experience (guilt, depression, anger) as a victim of rape or sexual assault.

- ◆ Provide emotional support if the patient is pregnant and if results are positive. Inform the patient that *Chlamydia* infection during pregnancy places the newborn at risk for pneumonia and conjunctivitis.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be

performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include culture bacterial (anal, genital), culture viral, gram stain, PAP smear, and syphilis serology.
- ◆ Refer to the Immune and Reproductive System tables at the end of the book for related tests by body system.

C

Chloride, Blood

SYNONYM/ACRONYM: Cl⁻.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Ion-selective electrode)

Age	Conventional Units	SI Units (Conventional Units × 1)
Premature	95–110 mEq/L	95–110 mmol/L
0–1 mo	98–113 mEq/L	98–113 mmol/L
2 mo–adult	97–107 mEq/L	97–107 mmol/L

DESCRIPTION: Chloride is the most abundant anion in the extracellular fluid. Its most important function is in the maintenance of acid-base balance, in which it competes with bicarbonate for sodium. Chloride levels generally increase and decrease proportional to sodium levels and inversely proportional to bicarbonate levels. Chloride also participates with sodium in the maintenance of water

balance and aids in the regulation of osmotic pressure. Chloride contributes to gastric acid (hydrochloric acid) for digestion and activation of enzymes. The chloride content of venous blood is slightly higher than that of arterial blood because chloride ions enter red blood cells in response to absorption of carbon dioxide into the cell. As carbon dioxide enters the blood cell, bicarbonate

leaves and chloride is absorbed in exchange to maintain electrical neutrality within the cell.

Chloride is provided by dietary intake, mostly in the form of sodium chloride. It is absorbed by the gastrointestinal system, filtered out by the glomeruli, and reabsorbed by the renal tubules. Excess chloride is excreted in the urine. Serum values normally remain fairly stable. A slight decrease may be detectable after meals because chloride is used to produce hydrochloric acid as part of the digestive process. Measurement of chloride levels is not as essential as measurement of other electrolytes such as sodium or potassium. Chloride is usually included in standard electrolyte panels to detect the presence of unmeasured anions via calculation of the anion gap. Chloride levels are usually not interpreted apart from sodium, potassium, carbon dioxide, and anion gap.

The patient's clinical picture needs to be considered in the evaluation of electrolytes. Fluid and electrolyte imbalances are often seen in patients with serious illness or injury because in these cases the clinical situation has affected the normal homeostatic balance of the body. It is also possible that therapeutic treatments being administered are causing or contributing to the electrolyte imbalance. Children and adults are at high risk for fluid and electrolyte imbalances when chloride levels are depleted. Children are considered to be at high risk during chloride imbalance because a positive serum chloride balance is important for expansion of the extracellular fluid compartment.

Anemia, the result of decreased hemoglobin levels, is a frequent issue for elderly patients. Because hemoglobin participates in a major buffer system in the body, depleted hemoglobin levels affect the efficiency of chloride ion exchange for bicarbonate in red blood cells, which in turn affects acid-base balance. Elderly patients are also at high risk because their renal response to change in pH is slower, resulting in a more rapid development of electrolyte imbalance.

INDICATIONS:

- Assist in confirming a diagnosis of disorders associated with abnormal chloride values, as seen in acid-base and fluid imbalances
- Differentiate between types of acidosis (hyperchloremic versus anion gap)
- Monitor effectiveness of drug therapy to increase or decrease serum chloride levels

RESULT:

Increased in:

- Acute renal failure (**Decreased renal excretion**)
- Cushing's disease (**Related to sodium retention as a result of increased levels of aldosterone; typically chloride levels follow sodium levels**)
- Dehydration (**Related to hemoconcentration**)
- Diabetes insipidus (**Hemoconcentration related to excessive urine production**)
- Excessive infusion of normal saline (**Excessive intake**)
- Head trauma with hypothalamic stimulation or damage
- Hyperparathyroidism (primary) (**High chloride phosphate ratio is used to assist in diagnosis**)

- Metabolic acidosis (**Associated with prolonged diarrhea**)
- Renal tubular acidosis (**Acidosis related to net retention of chloride ions**)
- Respiratory alkalosis (e.g., hyperventilation) (**Intracellular chloride is replaced by bicarbonate; chloride levels increase**)
- Salicylate intoxication (**Disturbance in acid base balance resulting in a hyperchloremic acidosis**)

Decreased in:

- Addison's disease (**Insufficient aldosterone is produced; potassium is retained while sodium and chloride are lost**)
- Burns (**Dilutional effect related to sequestration of extracellular fluid**)
- Congestive heart failure (**Dilutional effect of fluid buildup**)
- Diabetic ketoacidosis (**Disturbance in acid-base balance with accumulation of ketone bodies and increased chloride**)
- Excessive sweating (**Excessive loss of chloride without replacement**)
- Gastrointestinal loss from vomiting (severe), diarrhea, nasogastric suction, or fistula
- Metabolic alkalosis (**Intracellular chloride increases to reduce alkalinity of extracellular fluid**)
- Overhydration (**Dilutional effect**)
- Respiratory acidosis (chronic)
- Salt-losing nephritis (**Excessive loss**)
- Syndrome of inappropriate antidiuretic hormone secretion (**Dilutional effect**)
- Water intoxication (**Dilutional effect**)

CRITICAL VALUES:



Less than 80 mEq/L
Greater than 115 mEq/L

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms. Observe the patient for symptoms of critically decreased or elevated chloride levels. Proper interpretation of chloride values must be made within the context of other electrolyte values and requires clinical knowledge of the patient.

The following may be seen in hypochloremia: twitching or tremors, which may indicate excitability of the nervous system; slow and shallow breathing; and decreased blood pressure as a result of fluid loss. Possible interventions relate to treatment of the underlying cause.

Signs and symptoms associated with hyperchloremia are weakness, lethargy, and deep, rapid breathing. Proper interventions include treatments that correct the underlying cause.

INTERFERING FACTORS:

- Drugs that may cause an increase in chloride levels include acetazolamide, acetylsalicylic acid, ammonium chloride, androgens, bromide, chlorothiazide, cholestyramine, cyclosporine, estrogens, guanethidine, hydrochlorothiazide, lithium, methyl dopa, NSAIDs, oxyphenbutazone, phenylbutazone, and triamterene.
- Drugs that may cause a decrease in chloride levels include aldosterone, bicarbonate, corticosteroids, corticotropin, cortisone, diuretics, ethacrynic acid, furosemide, hydroflumethiazide, laxatives (if chronic abuse occurs), mannitol, meralluride, mersalyl, methyclothiazide, metolazone, and triamterene. Many of these drugs can cause a diuretic action that inhibits the tubular reabsorption of chloride. *Note:* Triamterene has nephrotoxic and azotemic effects, and when

organ damage has occurred, increased serum chloride levels result. Potassium chloride (found in salt substitutes) can lower blood chloride levels and raise urine chloride levels.

- Elevated triglyceride or protein levels may cause a volume-displacement error in the specimen, reflecting falsely decreased chloride values when chloride measurement methods employing predilution specimens are used (e.g., indirect ion-selective electrode, flame photometry).
- Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, falsely decreasing the result. There is also the potential of contaminating the sample with the normal saline contained in the IV solution, falsely increasing the result.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate electrolytes, acid-base balance, and hydration level.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, endocrine, gastrointestinal, genitourinary, and respiratory systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Specimens should not be collected during hemodialysis.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement. Instruct the patient not to clench and unclench fist immediately before or during specimen collection.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe the patient on saline IV fluid replacement therapy for signs of overhydration, especially in cases in which there is a history of cardiac or renal disease. Signs of overhydration include constant, irritable cough; chest rales; dyspnea; or engorgement of neck and hand veins.
- ▶ Evaluate the patient for signs and symptoms of dehydration. Check the patient's skin turgor, mucous membrane moisture, and ability to produce tears. Dehydration is a significant and common finding in geriatric and other patients in whom renal function has deteriorated.

Monitor daily weights as well as intake and output to determine whether fluid retention is occurring because of sodium and chloride excess. Patients at risk for or with a history of fluid imbalance are also at risk for electrolyte imbalance.

Nutritional considerations: Careful observation of the patient on IV fluid replacement therapy is important. A patient receiving a continuous 5% dextrose solution (D₅W) may not be taking in an adequate amount of chloride to meet the body's needs. The patient, if allowed, should be encouraged to drink fluids such as broths, tomato juice, or colas and to eat foods such as meats, seafood, or eggs, which contain sodium and chloride. The use of table salt may also be appropriate.

Nutritional considerations: Instruct patients with elevated chloride levels to avoid eating or drinking anything containing sodium chloride salt. The patient or caregiver should also be encouraged to read food labels to determine which products are suitable for a low-sodium diet.

Nutritional considerations: Instruct patients with low chloride levels that a decrease in iron absorption may

occur as a result of less chloride available to form gastric acid, which is essential for iron absorption. In prolonged periods of chloride deficit, iron-deficiency anemia could develop.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ACTH, anion gap, blood gases, carbon dioxide, complete blood count hematocrit, complete blood count hemoglobin, osmolality, potassium, protein total and fractions, and sodium.
- Refer to the Cardiovascular, Endocrine, Gastrointestinal, Genitourinary, and Respiratory System tables at the end of the book for related test by body system.

Chloride, Sweat

SYNONYM/ACRONYM: Sweat test, pilocarpine iontophoresis sweat test, sweat chloride.

SPECIMEN: Sweat (0.1 mL minimum) collected by pilocarpine iontophoresis.

REFERENCE VALUE: (Method: Ion-specific electrode or titration)

	Conventional Units	SI Units (Conventional Units × 1)
Normal	0–40 mEq/L	0–40 mmol/L
Borderline	41–60 mEq/L	41–60 mmol/L
Consistent with the diagnosis of CF	Greater than 60 mEq/L	Greater than 60 mmol/L

The result must be interpreted with regard to the patient's age and clinical presentation. The patient must be at least 48 hr old.

DESCRIPTION: Cystic fibrosis (CF) is a genetic disease that affects normal functioning of the exocrine glands, causing them to excrete large amounts of electrolytes. Patients with CF have sweat electrolyte levels two to five times normal. Sweat test values, with family history and signs and symptoms, are required to establish a diagnosis of CF. CF is transmitted as an autosomal recessive trait and is characterized by abnormal exocrine secretions within the lungs, pancreas, small intestine, bile ducts, and skin. Clinical presentation may include chronic problems of the gastrointestinal and/or respiratory system. Sweat conductivity is a screening method that estimates chloride levels. Sweat conductivity values greater than or equal to 50 mEq/L should be referred for quantitative analysis of sweat chloride. Testing of stool samples for decreased trypsin activity has been used as a screen for CF in infants and children, but this is a much less reliable method than the sweat test. In-vitro diagnostic (IVD) medical devices are available for noninvasive saliva DNA self-collection kits. Genetic testing can be reliably performed on the harvested DNA material to screen for genetic mutations associated with CF and can assist in confirming a diagnosis of CF, but the sweat electrolyte test is still considered the gold standard diagnostic for CF.

The sweat test is a noninvasive study done to assist in the diagnosis of CF when considered with other test results and physical assessments. This test is usually performed on children, although adults may also be

tested; it is not usually ordered on adults because results can be highly variable and should be interpreted with caution. Sweat for specimen collection is induced by a small electrical current carrying the drug pilocarpine. The test measures the concentration of chloride produced by the sweat glands of the skin. A high concentration of chloride in the specimen indicates the presence of CF. The sweat test is used less commonly to measure the concentration of sodium ions for the same purpose.

INDICATIONS:

- Assist in the diagnosis of CF
- Screen for CF in individuals with a family history of the disease
- Screen for suspected CF in children with recurring respiratory infections
- Screen for suspected CF in infants with failure to thrive and infants who pass meconium late
- Screen for suspected CF in individuals with malabsorption syndrome

RESULT:

Increased in:

Conditions that affect electrolyte distribution and excretion may produce false positive sweat test results.

- Addison's disease
- Alcoholic pancreatitis (***Dysfunction of CF gene linked to pancreatic disease susceptibility***)
- CF
- Chronic pulmonary infections (***Related to undiagnosed CF***)
- Congenital adrenal hyperplasia
- Diabetes insipidus
- Familial cholestasis
- Familial hypoparathyroidism
- Fucosidosis

- Glucose-6-phosphate dehydrogenase deficiency
- Hypothyroidism
- Mucopolysaccharidosis
- Nephrogenic diabetes insipidus
- Renal failure

Decreased in:

Conditions that affect electrolyte distribution and retention may produce false negative sweat test results.

- Edema
- Hypoaldosteronism
- Hypoproteinemia
- Sodium depletion

CRITICAL VALUES:




20 yr or younger: Greater than 60 mmol/L considered diagnostic of CF

Older than 20 years: Greater than 70 mmol/L considered diagnostic of CF

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms. Values should be interpreted with consideration of family history and clinical signs and symptoms.

The validity of the test result is affected tremendously by proper specimen collection and handling. Before proceeding with appropriate patient education and counseling, it is important to perform duplicate testing on patients whose results are in the diagnostic or intermediate ranges. A negative test should be repeated if test results do not support the clinical picture.

INTERFERING FACTORS:

- An inadequate amount of sweat may produce inaccurate results.
-  This test should not be performed on patients with skin disorders (e.g., rash, erythema, eczema).
- Improper cleaning of the skin or improper application of gauze pad or filter paper for collection affects test results.

- Hot environmental temperatures may reduce the sodium chloride concentration in sweat; cool environmental temperatures may reduce the amount of sweat collected.
- If the specimen container that stores the gauze or filter paper is handled without gloves, the test results may show a false increase in the final weight of the collection container.


NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of cystic fibrosis.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and respiratory systems, especially failure to thrive or CF in other family members, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient and caregiver. Encourage the caregiver to stay with and support the child during the test. The iontophoresis and specimen collection usually takes approximately 75 to 90 min. Address concerns about pain and explain that there is no pain associated with the test, but a stinging sensation may be experienced when the low electrical current is applied at the site.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- Instruct the patient to cooperate fully and to follow directions.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
-  The patient is placed in a position that will allow exposure of the site on the forearm or thigh. To ensure collection of an adequate amount of sweat in a small infant, two sites (right forearm and right thigh) can be used. The patient should be covered to prevent cool environmental temperatures from affecting sweat production. The site selected for iontophoresis should never be the chest or left side because of the risk of cardiac arrest from the electrical current.
- The site is washed with distilled water and dried. A positive electrode is attached to the site on the right forearm or right thigh and covered with a pad that is saturated with pilocarpine, a drug that stimulates sweating. A negative electrode is covered with a pad that is saturated with bicarbonate solution. Iontophoresis is achieved by supplying a low (4 to 5 mA) electrical current via the electrode for 12 to 15 min. Battery-powered equipment is preferred over an electrical outlet to supply the current.
- The electrodes are removed, revealing a red area at the site, and the site is washed with distilled water and dried to remove any possible contaminants on the skin.
- Preweighed disks made of filter paper are placed on the site with a forceps; to prevent evaporation of sweat collected at the site, the disks are covered with paraffin or plastic and sealed at the edges. The disks are left in place for about 1 hr. Distract the child with books or games to allay fears.
- After 1 hr, the paraffin covering is removed, and disks are placed in a preweighed container with a forceps. The container is sealed and sent

immediately to the laboratory for weighing and analysis of chloride content. At least 100 mg of sweat is required for accurate results.

- Terminate the test if the patient complains of burning at the electrode site. Reposition the electrode before the test is resumed.
- Promptly transport the specimen to the laboratory for processing and analysis. Do not directly handle the preweighed specimen container or filter paper.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient/caregiver.
- Observe the site for unusual color, sensation, or discomfort.
- Inform the patient and caregiver that redness at the site fades in 2 to 3 hr.
- Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
- Nutritional considerations:** If appropriate, instruct the patient and caregiver that nutrition may be altered because of impaired digestive processes associated with CF. Increased viscosity of exocrine gland secretion may lead to poor absorption of digestive enzymes and fat-soluble vitamins, necessitating oral intake of digestive enzymes with each meal, and calcium and vitamin (A, D, E, and K) supplementation. Malnutrition also is seen commonly in patients with chronic, severe respiratory disease for many reasons, including fatigue, lack of appetite, and gastrointestinal distress. Research has estimated that the daily caloric intake needed for children with CF between 4 and 7 yr may be 2000 to 2800 and for teens 3000 to 5000. Tube feeding may be necessary to supplement regular high-calorie meals. To prevent pulmonary infection and decrease the extent of lung tissue damage, adequate intake of vitamins A and C is also important. Excessive loss of sodium chloride through the sweat glands of a patient with CF may necessitate increased salt intake, especially in environments where increased sweating is induced. The importance of following the prescribed diet should be stressed to the patient and caregiver.

- ▶ If appropriate, instruct the patient and caregiver that ineffective airway clearance related to excessive production of mucus and decreased ciliary action may result. Chest physical therapy and the use of aerosolized antibiotics and mucus thinning drugs are an important part of the daily treatment regimen.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Help the patient and caregiver to cope with long-term implications. Recognize that anticipatory anxiety and grief related to potential lifestyle changes may be expressed when someone is faced with a chronic disorder. Provide information regarding genetic counseling and possible screening of other family members if appropriate. Provide contact information, if desired, for the Cystic Fibrosis Foundation (www.cff.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain that a positive sweat test alone is not diagnostic of CF; repetition of borderline and positive tests is generally recommended. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include α_1 -antitrypsin/phenotype, amylase, anion gap, biopsy chorionic villus, blood gases, fecal analysis, fecal fat, osmolality, phosphorus, potassium, and sodium.
- ▶ Refer to the Endocrine and Respiratory System tables at the end of the book for related tests by body system.

Cholangiography, Percutaneous Transhepatic

SYNONYM/ACRONYM: Percutaneous cholecystogram, PTC, PTHC.

AREA OF APPLICATION: Biliary system.

CONTRAST: Radiopaque iodine-based contrast medium.

DESCRIPTION: Percutaneous transhepatic cholangiography (PTC) is a test used to visualize the biliary system in order to evaluate persistent upper abdominal pain after cholecystectomy and to determine the presence and cause of obstructive jaundice.

The liver is punctured with a thin needle under fluoroscopic guidance, and contrast medium is injected as the needle is slowly withdrawn. This test visualizes the biliary ducts without depending on the gallbladder's concentrating ability.

The intrahepatic and extrahepatic biliary ducts, and occasionally the gallbladder, can be visualized to determine possible obstruction. In obstruction of the extrahepatic ducts, a catheter can be placed in the duct to allow external drainage of bile. Endoscopic retrograde cholangiopancreatography (ERCP) and PTC are the only methods available to view the biliary tree in the presence of jaundice. ERCP poses less risk and is probably done more often. PTC is an invasive procedure and has potential risks, including bleeding, septicemia, bile peritonitis, and extravasation of the contrast medium.

INDICATIONS:

- Aid in the diagnosis of obstruction caused by gallstones, benign strictures, malignant tumors, congenital cysts, and anatomic variations
- Determine the cause, extent, and location of mechanical obstruction
- Determine the cause of upper abdominal pain after cholecystectomy
- Distinguish between obstructive and nonobstructive jaundice

RESULT:

Normal findings in:

- Biliary ducts are normal in diameter, with no evidence of dilation, filling defects, duct narrowing, or extravasation.
- Contrast medium fills the ducts and flows freely.
- Gallbladder appears normal in size and shape.




Abnormal findings in:

- Anatomic biliary or pancreatic duct variations
- Biliary sclerosis
- Cholangiocarcinoma
- Cirrhosis

- Common bile duct cysts
- Gallbladder carcinoma
- Gallstones
- Hepatitis
- Nonobstructive jaundice
- Pancreatitis
- Sclerosing cholangitis
- Tumors, strictures, inflammation, or gallstones of the common bile duct

CRITICAL VALUES: N/A

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Patients with cholangitis. The injection of the contrast medium can increase biliary pressure, leading to bacteremia, septicemia, and shock.
- Patients with postoperative wound sepsis, hypersensitivity to iodine, or acute renal failure.
-  Patients with bleeding disorders, massive ascites, or acute renal failure.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects within the examination field which may inhibit organ visualization and cause unclear images

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Peritonitis may occur as a result of bile extravasation.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the examination room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the biliary ducts.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, and dyes.
- ▶ Obtain a history of the patient's GI and hepatobiliary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that this procedure is performed before an upper GI study or barium swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note time and date of last dose.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in the radiology department by a HCP, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives.
- ▶ Type and screen the patient's blood for possible transfusion.
- ▶ Inform the patient that a laxative and cleansing enema may be needed the day before the procedure, with cleansing enemas on the morning of the procedure depending on the institution's policy.
- ▶ Instruct the patient to remove all external metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the

procedure. Protocols may vary from facility to facility.

- ◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ◆ Ensure that the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- ◆ Ensure the patient has removed all external metallic objects from the area to be examined.
- ◆ Assess for completion of bowel preparation according to the institution's procedure.
- ◆ If the patient has a history of allergic reactions to any relevant substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ◆ Have emergency equipment readily available.
- ◆ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ◆ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ◆ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.
- ◆ Place the patient in the supine position on an exam table.
- ◆ A kidney, ureter, and bladder (KUB) or plain film is taken to ensure that no barium or stool will obscure visualization of the biliary system.
- ◆ An area over the abdominal wall is anesthetized, and the needle is inserted and advanced under fluoroscopic guidance. Contrast medium is injected when placement is confirmed by the free flow of bile.
- ◆ A specimen of bile may be sent to the laboratory for culture and cytological analysis.

- ◆ At the end of the procedure, the contrast medium is aspirated from the biliary ducts, relieving pressure on the dilated ducts.
- ◆ If an obstruction is found during the procedure, a catheter is inserted into the bile duct to allow drainage of bile.
- ◆ Maintain pressure over the needle insertion site for several hours if bleeding is persistent.
- ◆ Observe the needle site for bleeding, inflammation, or hematoma formation.
- ◆ Establish a closed and sterile drainage system if a catheter is left in place.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
- ◆ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ◆ Monitor for reaction to iodinated contrast medium, including rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ Renal function should be assessed before metformin is restarted.
- ◆ Observe the puncture site for signs of bleeding, hematoma formation, ecchymosis, or leakage of bile. Notify the HCP if any of these is present.
- ◆ Advise the patient to watch for symptoms of infection, such as pain, fever, increased pulse rate, and muscle aches.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be needed

to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

▶ Related tests include ALT, amylase, AMA, AST, biopsy liver, cancer antigens, cholangiography postoperative,

cholangiopancreatography endoscopic retrograde, CT abdomen, GGT, hepatitis antigens and antibodies (A, B, C), hepatobiliary scan, KUB studies, laparoscopy abdominal, lipase, MRI abdomen, peritoneal fluid analysis, pleural fluid analysis, and US liver and biliary tract.

▶ Refer to the Gastrointestinal and Hepatobiliary System tables in the back of the book for related tests by body system.

C

Cholangiography, Postoperative

SYNONYM/ACRONYM: T-tube cholangiography.

AREA OF APPLICATION: Gallbladder, bile ducts.

CONTRAST: Iodinated contrast medium.

DESCRIPTION: After cholecystectomy, a self-retaining, T-shaped tube may be inserted into the common bile duct. Postoperative (T-tube) cholangiography is a fluoroscopic and radiographic examination of the biliary tract that involves the injection of a contrast medium through the T-tube inserted during surgery. This test may be performed at the time of surgery and again 7 to 10 days after cholecystectomy to assess the patency of the common bile duct and to detect any remaining calculi. T-tube placement may also be done after a liver transplant because biliary duct obstruction or anastomotic leakage is possible. This test should be performed before any gastrointestinal (GI) studies using barium and after any studies involving the measurement of iodinated compounds.

INDICATIONS:

- Determine biliary duct patency before T-tube removal
- Identify the cause, extent, and location of obstruction after surgery

RESULT:

Normal findings in:

- Biliary ducts are normal in size.
- Contrast medium fills the ductal system and flows freely.


Abnormal findings in:

- Appearance of channels of contrast medium outside of the biliary ducts, indicating a fistula
- Filling defects, dilation, or shadows within the biliary ducts, indicating calculi or neoplasm



CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye.

The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Patients with cholangitis. The injection of the contrast medium can increase biliary pressure, leading to bacteremia, septicemia, and shock.
-  Patients with postoperative wound sepsis, hypersensitivity to iodine, or acute renal failure.

Factors that may impair clear imaging:

- Gas or feces in the GI tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Air bubbles resembling calculi may be seen if there is inadvertent injection of air.
- Peritonitis may occur as a result of bile extravasation.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur

before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.

- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the examination room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their radiation level.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses the biliary ducts.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics and dyes.
- ♦ Obtain a history of results of the patient's GI and hepatobiliary system, symptoms, and previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Ensure that this procedure is performed before an upper GI study or barium swallow.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals (see Appendix F).
- ♦ If contrast medium is scheduled to be used, patients receiving metformin (glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ♦ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of

discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in the radiology department by a HCP and takes approximately 30 to 60 minutes.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects in the area to be examined.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any relevant substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Clamp the T-tube 24 hr before and during the procedure, if ordered, to help prevent air bubbles from entering the ducts.
- ▶ An x-ray of the abdomen is obtained to determine if any residual contrast medium is present from previous studies.

- ▶ The patient is placed on an examination table in the supine position.
- ▶ The area around the T-tube is draped; the end of the T-tube is cleansed with 70% alcohol. If the T-tube site is inflamed and painful, a local anesthetic (e.g., lidocaine) may be injected around the site. A needle is inserted into the open end of the T-tube, and the clamp is removed.
- ▶ Contrast medium is injected, and fluoroscopy is performed to visualize contrast medium moving through the duct system.
- ▶ The patient may feel a bloating sensation in the upper right quadrant as the contrast medium is injected. The tube is clamped, and images are taken. A delayed image may be taken 15 min later to visualize passage of the contrast medium into the duodenum.
- ▶ For procedures done after surgery, the T-tube is removed if findings are normal; a dry, sterile dressing is applied to the site.
- ▶ If retained calculi are identified, the T-tube is left in place for 4 to 6 wk until the tract surrounding the T-tube is healed to perform a percutaneous removal.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Monitor T-tube site and change sterile dressing, as ordered.
- ▶ Instruct the patient on the care of the site and dressing changes.
- ▶ Monitor for reaction to iodinated contrast medium, including rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.

- ▶ Carefully monitor the patient for fatigue and fluid and electrolyte imbalance.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed

to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CT abdomen, hepatobiliary scan, KUB, MRI abdomen, and US liver and biliary system.
- ▶ Refer to the Gastrointestinal and Hepatobiliary System tables in the back of the book for tests by related body systems.

Cholangiopancreatography, Endoscopic Retrograde

SYNONYM/ACRONYM: ERCP.

AREA OF APPLICATION: Gallbladder, bile ducts, pancreatic ducts.

CONTRAST: Iodinated contrast medium.

DESCRIPTION: Endoscopic retrograde cholangiopancreatography (ERCP) allows direct visualization of the pancreatic and biliary ducts with a flexible endoscope and, after injection of contrast material, with x-rays. It allows the physician to view the pancreatic, hepatic, and common bile ducts and the ampulla of Vater. ERCP and percutaneous transhepatic cholangiography (PTC) are the only procedures that allow direct visualization of the biliary and pancreatic ducts. ERCP is less invasive and has less morbidity than PTC. It is useful in the evaluation of patients with jaundice, because the ducts can be visualized even when the patient's bilirubin level

is high. (In contrast, oral cholecystography and IV cholangiography are not able to visualize the biliary system when the patient has high bilirubin levels.) By endoscopy, the distal end of the common bile duct can be widened, and gallstones can be removed and stents placed in narrowed bile ducts to allow bile to be drained in jaundiced patients. During endoscopy, specimens of suspicious tissue can be taken for pathological review, and manometry pressure readings can be obtained from the bile and pancreatic ducts. ERCP is used in the diagnosis and follow-up of pancreatic disease.

INDICATIONS:

- Assess jaundice of unknown cause to differentiate biliary tract obstruction from liver disease
- Collect specimens for cytology
- Identify obstruction caused by calculi, cysts, ducts, strictures, stenosis, and anatomic abnormalities
- Retrieve calculi from the distal common bile duct and release strictures
- Perform therapeutic procedures, such as sphincterotomy and placement of biliary drains


RESULT:**Normal findings in:**

- Normal appearance of the duodenal papilla
- Patency of the pancreatic and common bile ducts

Abnormal findings in:

- Duodenal papilla tumors
- Pancreatic cancer
- Pancreatic fibrosis
- Pancreatitis
- Sclerosing cholangitis

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate

cleansing or failure to restrict food intake before the study

- Retained barium from a previous radiologic procedure
- Previous surgery involving the stomach or duodenum, which can make locating the duodenal papilla difficult
- A patient with Zenker's diverticulum involving the esophagus, who may be unable to undergo ERCP
- A patient with unstable cardiopulmonary status, blood coagulation defects, or cholangitis (test may have to be rescheduled unless the patient received antibiotic therapy before the test)
- A patient with known acute pancreatitis
- Incorrect positioning of the patient, which may produce poor visualization of the area to be examined
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the examination room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the biliary ducts.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, and dyes.
- ▶ Obtain a history of the patient's GI and hepatobiliary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that this procedure is performed before an upper GI study or barium swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a GI lab or radiology department, usually by a HCP, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives.

- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ Assess for completion of bowel preparation according to the institution's procedure.
- ▶ If the patient has a history of allergic reactions to any relevant substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate containers with the corresponding patient demographics, date, and time of collection if cytology samples are collected.
- ▶ Insert an IV line for administration of drugs, as needed.
- ▶ Administer ordered sedation.

- ▶ An x-ray of the abdomen is obtained to determine if any residual contrast medium is present from previous studies.
- ▶ The oropharynx is sprayed or swabbed with a topical local anesthetic.
- ▶ The patient is placed on an examination table in the left lateral position with the left arm behind the back and right hand at the side with the neck slightly flexed. A protective guard is inserted into the mouth to cover the teeth. A bite block can also be inserted to maintain adequate opening of the mouth.
- ▶ The endoscope is passed through the mouth with a dental suction device in place to drain secretions. A side-viewing flexible fiberoptic endoscope is passed into the duodenum, and a small cannula is inserted into the duodenal papilla (ampulla of Vater).
- ▶ The patient is placed in the prone position. The duodenal papilla is visualized and cannulated with a catheter. Occasionally the patient can be turned slightly to the right side to aid in visualization of the papilla.
- ▶ IV glucagon or anticholinergics can be administered to minimize duodenal spasm and to facilitate visualization of the ampulla of Vater.
- ▶ ERCP manometry can be done at this time to measure the pressure in the bile duct, pancreatic duct, and sphincter of Oddi at the papilla area via the catheter as it is placed in the area before the contrast medium is injected.
- ▶ When the catheter is in place, contrast medium is injected into the pancreatic and biliary ducts via the catheter, and fluoroscopic images are taken. Biopsy specimens for cytological analysis may be obtained.
- ▶ Place specimens in appropriate containers, label them properly, and promptly transport them to the laboratory.
- ▶ after 24 hr, or as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Monitor for reaction to iodinated contrast medium, including rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Tell the patient to expect some throat soreness and possible hoarseness. Advise the patient to use warm gargles, lozenges, ice packs to the neck, or cool fluids to alleviate throat discomfort.
- ▶ Inform the patient that any belching, bloating, or flatulence is the result of air insufflation.
- ▶ Emphasize that any severe pain, fever, difficulty breathing, or expectoration of blood must be reported to the HCP immediately.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Do not allow the patient to eat or drink until the gag reflex returns, after which the patient is permitted to eat lightly for 12 to 24 hr.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity

RELATED MONOGRAPHS:

- ▶ Related tests include amylase, CT abdomen, hepatobiliary scan, KUB studies, lipase, MRI abdomen, peritoneal fluid analysis, pleural fluid analysis, and US liver and biliary system.
- ▶ Refer to the Gastrointestinal and Hepatobiliary System tables in the back of the book for related tests by body system.

Cholesterol, HDL and LDL

SYNONYM/ACRONYM: α_1 -Lipoprotein cholesterol, high-density cholesterol, HDLC, and β -lipoprotein cholesterol, low-density cholesterol, LDLC.

SPECIMEN: Serum (2 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Spectrophotometry)

HDLC	Conventional Units	SI Units (Conventional Units \times 0.0259)
Birth	6–56 mg/dL	0.16–1.45 mmol/L
Children and adults		
Desirable	Greater than 60 mg/dL	Greater than 1.56 mmol/L
Acceptable	40–60 mg/dL	0.9–1.56 mmol/L
Low	Less than 40 mg/dL	Less than 0.9 mmol/L

LDLC	Conventional Units	SI Units (Conventional Units \times 0.0259)
Optimal	Less than 100 mg/dL	Less than 2.59 mmol/L
Near optimal	100–129 mg/dL	2.59–3.34 mmol/L
Borderline high	130–159 mg/dL	2.67–4.11 mmol/L
High	160–189 mg/dL	4.14–4.90 mmol/L
Very high	Greater than 190 mg/dL	Greater than 4.92 mmol/L

	NMR LDLC Particle Number	NMR LDLC Small Particle Size
High-Risk CAD Patients	Less than 1000 nmol/L (Less than 20th percentile)	Less than 850 nmol/L
Moderately High-Risk CAD Patients	Less than 1300 nmol/L (Less than 50th percentile)	Less than 850 nmol/L

CAD = coronary artery disease; NMR = nuclear magnetic resonance

DESCRIPTION: High-density lipoprotein cholesterol (HDL) and low-density lipoprotein cholesterol (LDL) are the major transport proteins for cholesterol in the body. It is believed that HDL

may have protective properties in that its role includes transporting cholesterol from the arteries to the liver. LDL is the major transport protein for cholesterol to the arteries from the liver. LDL can be

calculated using total cholesterol, total triglycerides, and HDLC levels. Beyond the total cholesterol, HDL and LDL cholesterol values, other important risk factors must be considered. The Framingham algorithm can assist in estimating the risk of developing coronary artery disease (CAD) within a 10-yr period. The National Cholesterol Education Program (NCEP) also provides important guidelines. The latest NCEP guidelines for target lipid levels, major risk factors, and therapeutic interventions are outlined in Adult Treatment Panel III (ATP III) (nhlbi.nih.gov/guidelines/cholesterol/index.htm).

Studies have shown that CAD is inversely related to LDLC particle number and size. The NMR lipid profile uses NMR imaging spectroscopy to determine LDLC particle number and size in addition to measurement of the traditional lipid markers.

HDLC levels less than 40 mg/dL in men and women represent a coronary risk factor. There is an inverse relationship between HDLC and risk of CAD (i.e., lower HDLC levels represent a higher risk of CAD). Levels of LDLC in terms of risk for CAD are directly proportional to risk and vary by age group. The LDLC can be estimated using the Friedewald formula:

$$\text{LDLC} = (\text{Total Cholesterol}) - (\text{HDLC}) - (\text{VLDLC})$$

Very-low-density lipoprotein cholesterol (VLDLC) is estimated by dividing the triglycerides (conventional units) by 5. Triglycerides in SI units would be divided by 2.18 to estimate VLDLC. It is important to note that the formula is valid only if the triglycerides are less than 400 mg/dL or 4.52 mmol/L.

INDICATIONS:

- Determine the risk of cardiovascular disease
- Evaluate the response to dietary and drug therapy for hypercholesterolemia
- Investigate hypercholesterolemia in light of family history of cardiovascular disease

RESULT:

Although the exact pathophysiology is unknown, cholesterol is required for many functions at the cellular and organ level. Elevations of cholesterol are associated with conditions caused by an inherited defect in lipoprotein metabolism, liver disease, kidney disease, or a disorder of the endocrine system. Decreases in cholesterol levels are associated with conditions caused by malnutrition, malabsorption, liver disease, and sudden increased utilization.

HDLC increased in:

- Alcoholism
- Biliary cirrhosis
- Chronic hepatitis
- Exercise
- Familial hyper- α -lipoproteinemia

HDLC decreased in:

- Abetalipoproteinemia
- Cholestasis
- Chronic renal failure
- Fish-eye disease
- Genetic predisposition or enzyme/cofactor deficiency
- Hepatocellular disorders
- Hypertriglyceridemia
- Nephrotic syndrome
- Obesity
- Premature CAD
- Sedentary lifestyle
- Smoking
- Tangier disease
- Syndrome X (metabolic syndrome)
- Uncontrolled diabetes

LDLC increased in:

- Anorexia nervosa
- Chronic renal failure
- Corneal arcus
- Cushing's syndrome
- Diabetes
- Diet high in cholesterol and saturated fat
- Dysglobulinemias
- Hepatic disease
- Hepatic obstruction
- Hyperlipoproteinemia types IIA and IIB
- Hypothyroidism
- Nephrotic syndrome
- Porphyria
- Pregnancy
- Premature CAD
- Syndrome X (metabolic syndrome)
- Tendon and tuberous xanthomas

LDLC decreased in:

- Acute stress (severe burns, illness)
- Chronic anemias
- Chronic pulmonary disease
- Genetic predisposition or enzyme/cofactor deficiency
- Hyperthyroidism
- Hypolipoproteinemia and abetalipoproteinemia
- Inflammatory joint disease
- Myeloma
- Reye's syndrome
- Severe hepatocellular destruction or disease
- Tangier disease

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase HDLC levels include albuterol, anticonvulsants, cholestyramine, cimetidine, clofibrate and other fibric acid derivatives, estrogens, ethanol (moderate use), lovastatin, niacin, oral contraceptives, pindolol, pravastatin, prazosin, and simvastatin.
- Drugs that may decrease HDLC levels include acebutolol, atenolol, danazol, diuretics, etretinate,

interferon, isotretinoin, linseed oil, metoprolol, neomycin, nonselective β -adrenergic blocking agents, probucol, progesterone, steroids, and thiazides.

- Drugs that may increase LDLC levels include androgens, catecholamines, chenodiol, cyclosporine, danazol, diuretics, etretinate, glucogenic corticosteroids, and progestins.
- Drugs that may decrease LDLC levels include aminosalicic acid, cholestyramine, colestipol, estrogens, fibric acid derivatives, interferon, lovastatin, neomycin, niacin, pravastatin, prazosin, probucol, simvastatin, terazosin, and thyroxine.
- Some of the drugs used to lower total cholesterol and LDLC or increase HDLC may cause liver damage.
- Grossly elevated triglyceride levels invalidate the Friedewald formula for mathematical estimation of LDLC; if the triglyceride level is greater than 400 mg/dL, the formula should not be used.
- Fasting before specimen collection is highly recommended. Ideally, the patient should be on a stable diet for 3 wk and fast for 12 hr before specimen collection.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess and monitor risk for coronary artery disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's cardiovascular system and results of previously performed laboratory tests and diagnostic and surgical procedures. The presence of other risk factors, such as family history of heart disease, smoking, obesity, diet, lack of physical activity, hypertension, diabetes, previous myocardial infarction, and previous vascular disease, should be investigated.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to fast for 12 hr before specimen collection. Protocols may vary from facility to facility.
- ▶ Confirm with the requesting health care provider (HCP) that the patient should withhold medications known to influence test results, and instruct the patient accordingly.
- ▶ There are no fluid restrictions unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions as well as other pretesting preparations; assure that food has been restricted for at least 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site

for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, and medications, as directed by the HCP.
- ▶ **Nutritional considerations:** Decreased HDLC level and increased LDLC level may be associated with CAD. Nutritional therapy is recommended for the patient identified to be at high risk for developing CAD. If overweight, the patient should be encouraged to achieve a normal weight. The American Heart Association Step 1 and Step 2 diets may be helpful in achieving a goal of lowering total cholesterol and triglyceride levels. The Step 1 diet emphasizes a reduction in foods high in saturated fats and cholesterol. Red meats, eggs, and dairy products are the major sources of saturated fats and cholesterol. If triglycerides also are elevated, the patient should be advised to eliminate or reduce alcohol and simple carbohydrates from the diet. The Step 2 diet recommends stricter reductions.
- ▶ **Social and cultural considerations:** Numerous studies point to the prevalence of excess body weight in American children and adolescents. Experts estimate that obesity is present in 25% of the population ages 6 to 11. The medical, social, and emotional consequences of excess body weight are significant. Special attention should be given to instructing the child and caregiver regarding health risks and weight-control education.
- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Heart Association

(www.americanheart.org), or the National Heart, Lung, and Blood Institute (nhlbi.nih.gov).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, ANP, blood gases, BNP, calcium (total and ionized), cholesterol total, CT cardiac scoring, CRP, CK and isoenzymes, echocardiography, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI chest, MI scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, triglycerides, and troponin.
- ▶ Refer to the Cardiovascular System table at the back of the book for related tests by body system.



Cholesterol, Total

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable. It is important to use the same tube type when serial specimen collections are anticipated for consistency in testing.

REFERENCE VALUE: (Method: Spectrophotometry)

Serum

Risk	Conventional Units	SI Units (Conventional Units × 0.0259)
Children and Adolescents (Less than 20 y)		
Desirable	Less than 170 mg/dL	Less than 4.4 mmol/L
Borderline	170–199 mg/dL	4.4–5.2 mmol/L
High	Greater than 200 mg/dL	Greater than 5.2 mmol/L
Adults		
Desirable	Less than 200 mg/dL	Less than 5.18 mmol/L
Borderline	200–239 mg/dL	5.18–6.19 mmol/L
High	Greater than 240 mg/dL	Greater than 6.22 mmol/L

Plasma values may be 10% lower than serum values.

DESCRIPTION: Cholesterol is a lipid needed to form cell membranes and a component of the materials that render the skin waterproof. It also helps form bile salts, adrenal corticosteroids, estrogen, and androgens. Cholesterol is obtained from the diet (exogenous cholesterol) and also synthesized in the body (endogenous cholesterol). Although most body cells can form some cholesterol, it is produced mainly by the liver and intestinal mucosa. Cholesterol is an integral component in cell membrane maintenance and hormone production. Very low cholesterol values, as are sometimes seen in critically ill patients, can be as life-threatening as very high levels.

According to the National Cholesterol Education Program, maintaining cholesterol levels less than 200 mg/dL significantly reduces the risk of coronary heart disease; no age and gender stratification is presented as part of its recommendation. Numerous studies have been done, and there are inconsistencies among the studies as to target “normals” segregated by age and gender. Beyond the total cholesterol and high-density lipoprotein cholesterol (HDL) values, other important risk factors must be considered. The Framingham algorithm can assist in estimating the risk of developing coronary artery disease (CAD) within a 10-yr period. Many myocardial infarctions occur even in patients whose cholesterol levels are considered to be within acceptable limits or who are in a moderate-risk category. The combination of risk factors and lipid values helps identify individuals at risk so that appropriate interventions

can be taken. If the cholesterol level is greater than 200 mg/dL, repeat testing after a 12- to 24-hr fast is recommended.

INDICATIONS:

- Assist in determining risk of cardiovascular disease
- Assist in the diagnosis of nephrotic syndrome, hepatic disease, pancreatitis, and thyroid disorders
- Evaluate the response to dietary and drug therapy for hypercholesterolemia
- Investigate hypercholesterolemia in light of family history of cardiovascular disease

RESULT:

Increased in:

Although the exact pathophysiology is unknown, cholesterol is required for many functions at the cellular and organ level. Elevations of cholesterol are associated with conditions caused by an inherited defect in lipoprotein metabolism, liver disease, kidney disease, or a disorder of the endocrine system.

- Acute intermittent porphyria
- Alcoholism
- Anorexia nervosa
- Cholestasis
- Chronic renal failure
- Diabetes (with poor control)
- Diets high in cholesterol and fats
- Familial hyperlipoproteinemia
- Glomerulonephritis
- Glycogen storage disease (von Gierke disease)
- Gout
- Hypothyroidism (primary)
- Ischemic heart disease
- Nephrotic syndrome
- Obesity
- Pancreatic and prostatic malignancy
- Pregnancy

- Syndrome X (metabolic syndrome)
- Werner's syndrome

Decreased in:

Although the exact pathophysiology is unknown, cholesterol is required for many functions at the cellular and organ level. Decreases in cholesterol levels are associated with conditions caused by malnutrition, malabsorption, liver disease, and sudden increased utilization.

- Burns
- Chronic myelocytic leukemia
- Chronic obstructive pulmonary disease
- Hyperthyroidism
- Liver disease (severe)
- Malabsorption and malnutrition syndromes
- Myeloma
- Pernicious anemia
- Polycythemia vera
- Severe illness
- Sideroblastic anemias
- Tangier disease
- Thalassemia
- Waldenström's macroglobulinemia

CRITICAL VALUES: N/A.

INTERFERING FACTORS:

- Drugs that may increase cholesterol levels include amiodarone, androgens, catecholamines, cyclosporine, danazol, diclofenac, disulfiram, glucogenic corticosteroids, ibuprofen, isotretinoin, levodopa, methylothiazide, miconazole (owing to castor oil vehicle, not the drug), nafarelin, nandrolone, some oral contraceptives, oxymetholone, phenobarbital, phenothiazine, prochlorperazine, and sotalol.
- Drugs that may decrease cholesterol levels include acebutolol, amiloride, aminosalicic acid, ascorbic acid, asparaginase, atenolol, atorvastatin, beclobrate, bezafibrate, carbutamide, cerivastatin, cholestyramine, ciprofibrate,

clofibrate, clonidine, colestipol, dextrothyroxine, doxazosin, enalapril, estrogens, fenfluramine, fenofibrate, fluvastatin, gemfibrozil, haloperidol, hydralazine, interferon, lovastatin, neomycin, niacin, pravastatin, probucol, simvastatin, tamoxifen, terazosin, thyroxine, ursodiol, and verapamil.

- Ingestion of alcohol 12 to 24 hr before the test can falsely elevate results.
- Ingestion of drugs that alter cholesterol levels within 12 hr of the test may give a false impression of cholesterol levels, unless the test is done to evaluate such effects.
- Positioning can affect results; lower levels are obtained if the specimen is from a patient who has been supine for 20 min.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess and monitor risk for coronary artery disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, gastrointestinal, hematopoietic, and hepatobiliary systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures. The presence of other risk factors, such as family history of heart disease, smoking, obesity, diet, lack of physical activity, hypertension, diabetes, previous myocardial

infarction, and previous vascular disease, should be investigated.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to withhold alcohol and drugs known to alter cholesterol levels for 12 to 24 hr before specimen collection, at the direction of the health care provider (HCP).
- ▶ There are no fluid or medication restrictions unless by medical direction.
- ▶ Fasting 6 to 12 hr before specimen collection is required if triglyceride measurements are included; it is recommended if cholesterol levels alone are measured for screening. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions and pretesting preparations; assure that food has been restricted for at least 6 to 12 hr prior to the procedure if triglycerides are to be measured.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet as directed by the HCP.
- ▶ Secondary causes for increased cholesterol levels should be ruled out before therapy to decrease levels is initiated by use of drugs.
- ▶ **Nutritional considerations:** Increases in total cholesterol levels may be associated with CAD. Nutritional therapy is recommended for patients identified to be at high risk for developing CAD. If overweight, the patient should be encouraged to achieve a normal weight. The American Heart Association Step 1 and Step 2 diets may be helpful in achieving a goal of lowering total cholesterol and triglyceride levels. The Step 1 diet emphasizes a reduction in foods high in saturated fats and cholesterol. Red meats, eggs, and dairy products are the major sources of saturated fats and cholesterol. If triglycerides are also elevated, the patient should be advised to eliminate or reduce alcohol and simple carbohydrates from the diet. The Step 2 diet recommends stricter reductions.
- ▶ **Social and cultural considerations:** Numerous studies point to the prevalence of excess body weight in American children and adolescents. Experts estimate that obesity is present in 25% of the population ages 6 to 11. The medical, social, and emotional consequences of excess body weight are significant. Special attention should be given to instructing the child and caregiver regarding health risks and weight-control education.
- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling

services. Provide contact information, if desired, for the American Heart Association (www.americanheart.org), or the National Heart, Lung, and Blood Institute (www.nhlbi.nih.gov).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, ANP, blood gases, BNP, calcium, cholesterol (HDL and LDL), CT cardiac scoring, CRP, CK and isoenzymes, echocardiography, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, MRI chest, magnesium, MI scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, triglycerides, and troponin.
- ▶ Refer to the Cardiovascular, Gastrointestinal, Hematopoietic, and Hepatobiliary System tables at the back of the book for related tests by body system.

Chromosome Analysis, Blood

SYNONYM/ACRONYM: N/A.

SPECIMEN: Whole blood (2 mL) collected in green-top (sodium heparin) tube.

REFERENCE VALUE: (Method: Tissue culture and microscopic analysis) No chromosomal abnormalities identified.

DESCRIPTION: Testing for birth defects as well as mental and physical retardation can be accomplished through the use of several technologies. Chromosome analysis by phytohemagglutination assay is used to detect Down syndrome and abnormal sexual development. Fluorescence in situ hybridization (FISH) testing is useful in the detection of specific microdeletion syndromes (e.g., Prader-Willi, Angelman, Beckwith-Wiedemann, Smith-Magenis, DiGeorge, Williams, Miller-Dieker) and

other acquired chromosomal changes associated with hematologic disorders. Amniotic fluid, chorionic villus sampling, and cells from fetal tissue or products of conception can also be evaluated for chromosomal abnormalities.

INDICATIONS:

- Evaluate conditions related to cryptorchidism, hypogonadism, primary amenorrhea, and infertility
- Evaluate congenital anomaly, delayed development (physical or

mental), mental retardation, and ambiguous sexual organs

- Investigate the carrier status of patients or relatives with known genetic abnormalities
- Investigate the cause of multiple miscarriages
- Provide prenatal care or genetic counseling

RESULT:

The following tables list some common genetic defects:

Syndrome	Autosomal Chromosome Defect	Features
Beckwith-Wiedemann	Duplication 11p15	Macroglossia, omphalocele, earlobe creases
Cat's eye	Trisomy 2q11	Anal atresia, coloboma
Cri du chat	Deletion 5p	Catlike cry, microcephaly, hypertelorism, mental retardation, retrognathia
Down	Trisomy 21	Epicanthal folds, simian crease of palm, flat nasal bridge, mental retardation, congenital heart disease
Edwards'	Trisomy 18	Micrognathia, clenched third/fourth fingers with the fifth finger overlapping, rocker-bottom feet, mental retardation, congenital heart disease
Pallister-Killian	Trisomy 12p	Psychomotor delay, sparse anterior scalp hair, micrognathia, hypotonia
Patau	Trisomy 13	Microcephaly, cleft palate or lip, polydactyly, mental retardation, congenital heart disease
Warkam	Mosaic trisomy 8	Malformed ears, bulbous nose, deep palm creases, absent or hypoplastic patellae
Wolf-Hirschhorn	Deletion 4p	Microcephaly, growth retardation, mental retardation, carp mouth

Syndrome	Sex-Chromosome Defect	Features
XYY	47,XYY	Tall, increased risk of behavior problems
Klinefelter's	47,XXY	Hypogonadism, infertility, underdeveloped secondary sex characteristics, learning disabilities
Triple X	47,XXX	Increased risk of infertility and learning disabilities
Ullrich-Turner	45,X	Short, gonadal dysgenesis, webbed neck, low posterior hairline, renal and cardiovascular abnormalities

CRITICAL VALUES: N/A**INTERFERING FACTORS:** N/A**NURSING IMPLICATIONS
AND PROCEDURE****PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate suspected chromosomal disorders.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's reproductive system, family history of known or suspected genetic disorders, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the

- patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of the sensitive nature of the testing. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ **Social and cultural considerations:** Encourage the family to seek counseling if they are contemplating pregnancy termination or to seek genetic counseling if a chromosomal abnormality is determined. Decisions regarding elective abortion should occur in the presence of both parents. Provide a nonjudgmental, nonthreatening atmosphere for discussing the risks and difficulties of delivering and raising a developmentally challenged infant, as well as exploring other options (termination of pregnancy or adoption). It is also important to discuss feelings the mother and father may experience (e.g., guilt, depression, anger) if fetal abnormalities are detected. Educate the patient and family regarding access to counseling services, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor changes in health status and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include α_1 -fetoprotein, amniotic fluid analysis, biopsy chorionic villus, and US biophysical profile obstetric.
- Refer to the Reproductive System table at the end of the book for related tests by body system.

C

Clot Retraction

SYNONYM/ACRONYM: N/A.

SPECIMEN: Whole blood collected in a full 5-mL red-top tube.

REFERENCE VALUE: (Method: Macroscopic observation of sample) A normal clot, gently separated from the side of the test tube and incubated at 37°C shrinks to about half of its original size within 1 hr. The result is a firm, cylindrical fibrin clot that contains red blood cells and is sharply demarcated from the clear serum. Complete clot retraction can take 6 to 24 hr.

DESCRIPTION: The clot retraction test measures the adequacy of platelet function by measuring the speed and extent of clot retraction. Normally, when blood clots in a test tube, it retracts away from the sidewalls of the tube. Platelets play a major role in the clot retraction process. When platelets are decreased or function is impaired, scant serum and a soft, plump, poorly demarcated clot form in the tube. In addition to normal platelets, clot retraction depends on the contractile protein thrombosthenin, magnesium, adenosine triphosphate (ATP), and pyruvate kinase. Clot retraction is also influenced by hematocrit and by fibrinogen structure and concentration.

INDICATIONS:

- Evaluate the adequacy of platelet function
- Evaluate thrombocytopenia of unknown origin
- Investigate the possibility of Glanzmann's disease
- Investigate suspected abnormalities of fibrinogen or fibrinolytic activity

RESULT:

Increased in: N/A.

Decreased in:
Glanzmann's thrombasthenia

CRITICAL VALUES: N/A.

INTERFERING FACTORS:

- Drugs that may produce a decreased result include apronalide, carbenicillin, and plicamycin.
- Platelet count less than $100 \times 10^3/\text{mm}^3$, acetylsalicylic acid

therapy, altered fibrinogen/fibrin structure, hypofibrinogenemia, polycythemia or hemoconcentration, and multiple myeloma are conditions in which abnormal clot retraction may occur, limiting the ability to form a valid assessment of platelet function.

- Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results. Specimens received in the laboratory more than 1 hr after collection should be rejected.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of bleeding disorders.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory within 1 hr of collection for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Inform the patient with abnormal clot retraction of the importance of taking precautions against bruising and bleeding. These precautions may include the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of acetylsalicylic acid and similar products, and avoidance of intramuscular injections.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include bleeding time, coagulation factor XIII, complete blood count, complete blood count hematocrit, complete blood count hemoglobin, and complete blood count platelet count and fibrinogen.
- ▶ Refer to the Hematopoietic System table at the end of the book for related tests by body system.

Coagulation Factors

SYNONYM/ACRONYM: See table.

SPECIMEN: Whole blood in a completely filled 5-mL blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Photo-optical clot detection) Activity from 50% to 150%.

	Preferred Name	Synonym
Factor I	Fibrinogen	–
Factor II	Prothrombin	Prethrombin
Factor III	Tissue factor	Tissue thromboplastin
Factor IV	Calcium	Ca ²⁺
Factor V	Proaccelerin	Labile factor, accelerator globulin (AcG)
Factor VII	Proconvertin	Stabile factor, serum prothrombin conversion accelerator, autoprothrombin I
Factor VIII:C	Antihemophilic factor (AHF)	Antihemophilic globulin (AHG), antihemophilic factor A, platelet cofactor 1
Factor IX	Plasma thromboplastin component (PTC)	Christmas factor, antihemophilic factor B, platelet cofactor 2
Factor X	Stuart-Prower factor	Autoprothrombin III, thrombokinase
Factor XI	Plasma thromboplastin antecedent (PTA)	Antihemophilic factor C
Factor XII	Hageman factor	Glass factor, contact factor
Factor XIII	Fibrin-stabilizing factor (FSF) Prekallikrein High-molecular-weight kininogen (HMWK)	Laki-Lorand factor (LLF), fibrinase, plasma transglutininase Fletcher factor Fitzgerald factor, contact activation cofactor, Williams factor, Flauijeac factor

DESCRIPTION: The coagulation proteins respond to blood vessel injury in a chain of events. The intrinsic and extrinsic pathways of secondary hemostasis are a series of reactions involving the substrate protein fibrinogen, the coagulation factors (also known

as *enzyme precursors* or *zymogens*), nonenzymatic cofactors (Ca²⁺), and phospholipids. The factors were assigned Roman numerals in the order of their discovery, not their place in the coagulation sequence. Factor VI was originally thought to be a

separate clotting factor. It was subsequently proved to be the same as a modified form of Factor V, and therefore the number is no longer used.

The coagulation factors are formed in the liver. They can be divided into three groups based on their common properties:

1. The contact group is activated in vitro by a surface such as glass and is activated in vivo by collagen. The contact group includes factor XI, factor XII, prekallikrein, and high-molecular-weight kininogen.
2. The prothrombin or vitamin K–dependent group includes factors II, VII, IX, and X.
3. The fibrinogen group includes factors I, V, VIII, and XIII. They are the most labile of the factors and are consumed during the coagulation process. The factors listed in the table are the ones most commonly measured.

INDICATIONS:

- Identify the presence of inherited bleeding disorders
- Identify the presence of qualitative or quantitative factor deficiency

RESULT:

Increased in: N/A

Decreased in:

- Congenital deficiency
- Disseminated intravascular coagulation (**Factors are consumed as part of the coagulation cascade**)
- Liver disease (**Many coagulation factors are synthesized by the liver**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase factor II levels include fluoxymesterone,

methandrostenolone, nandrolone, and oxymetholone.

- Drugs that may decrease factor II levels include warfarin.
- Drugs that may increase factor V, VII, and X levels include anabolic steroids, fluoxymesterone, methandrostenolone, nandrolone, oral contraceptives, and oxymetholone.
- Drugs that may decrease factor V levels include streptokinase.
- Drugs that may decrease factor VII levels include acetylsalicylic acid, asparaginase, cefamandole, ceftriaxone, dextran, dicumarol, gemfibrozil, oral contraceptives, and warfarin.
- Drugs that may increase factor VIII levels include chlormadinone.
- Drugs that may decrease factor VIII levels include asparaginase.
- Drugs that may increase factor IX levels include chlormadinone and oral contraceptives.
- Drugs that may decrease factor IX levels include asparaginase and warfarin.
- Drugs that may decrease factor X levels include chlormadinone, dicumarol, oral contraceptives, and warfarin.
- Drugs that may decrease factor XI levels include asparaginase and captopril.
- Drugs that may decrease factor XII levels include captopril.
- Test results of patients on anticoagulant therapy are unreliable.
- Placement of tourniquet for longer than 1 min can result in venous stasis and changes in the concentration of plasma proteins to be measured. Platelet activation may also occur under these conditions, causing erroneous results.
- Vascular injury during phlebotomy can activate platelets and coagulation factors, causing erroneous results.

- Hemolyzed specimens must be rejected because hemolysis is an indication of platelet and coagulation factor activation.
- Icteric or lipemic specimens interfere with optical testing methods, producing erroneous results.
- Incompletely filled collection tubes, specimens contaminated with heparin, clotted specimens, or unprocessed specimens not delivered to the laboratory within 1 hr of collection should be rejected.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to detect factor deficiencies and related coagulopathies.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and hepatobiliary systems, any bleeding disorders, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications. Include anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. *Important note:* Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to inquire from the laboratory which concentration it recommends, because each concentration will have its own specific reference range. When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with tissue thromboplastin.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed samples stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to report immediately any signs of unusual bleeding or bruising.
- ▶ Inform the patient with decreased factor levels of the importance of taking precautions against bruising and bleeding. These precautions may include the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of acetylsalicylic acid and similar products, and avoidance of intramuscular injections.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.

Answer any questions or address any concerns voiced by the patient or family. Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include aPTT, ALT, ALP, AT-III, AST, clot retraction, complete blood count, platelet count, copper, fibrinogen, FDP, plasminogen, protein C, protein S, PT/INR, and vitamin K.
- ▶ Refer to the Hematopoietic and Hepatobiliary System tables at the end of the book for related tests by body system.

Cold Agglutinin Titer

SYNONYM/ACRONYM: Mycoplasma serology.

SPECIMEN: Serum (2 mL) collected in a red-top tube. The tube must be placed in a water bath or heat block at 37°C for 1 hr and allowed to clot before the serum is separated from the red blood cells (RBCs).

REFERENCE VALUE: (Method: Patient serum containing autoantibodies titered against type O RBCs at 2°C to 8°C. Type O cells are used because they have no antigens on the cell membrane surface. Agglutination with patient sera would not occur because of reaction between RBC blood type antigens and patient blood type antibodies.) Negative: Single titer less than 1:32 or less than a fourfold increase in titer over serial samples.

DESCRIPTION: Cold agglutinins are antibodies that cause clumping or agglutination of RBCs at cold temperatures in individuals with certain conditions or who are infected by

particular organisms. Cold agglutinins are associated with *Mycoplasma pneumoniae* infection. *M. pneumoniae* has I antigen specificity to human RBC membranes. Fetal cells largely

contain I antigens, but by 18 months most cells carry the I antigen. The agglutinins are usually immunoglobulin M (IgM) antibodies and cause agglutination of cells at temperatures in the range of 0°C to 10°C. The temperature of circulating blood in the extremities may be lower than core temperatures. RBCs of affected individuals may agglutinate and obstruct blood vessels in fingers, toes, and ears, or they may initiate the complement cascade. Affected cells may be lysed immediately within the capillaries and blood vessels as a result of the action of complement on the cell wall, or they may return to the circulatory system and be lysed in the spleen by macrophages.

The titer endpoint is the highest dilution of serum that shows a specific antigen-antibody reaction. Single titers greater than 1:64, or a fourfold increase in titer between specimens collected 5 or more days apart, are clinically significant. Patients affected with primary atypical viral pneumonia exhibit a rise in titer 8 to 10 days after the onset of illness. IgM antibodies peak in 12 to 25 days and begin to diminish 30 days after onset.

INDICATIONS:

- Assist in the confirmation of primary atypical pneumonia, influenza, or pulmonary embolus
- Provide additional diagnostic support for cold agglutinin disease associated with viral infections or lymphoreticular cancers

RESULT:

Increased in:

- Infectious mononucleosis
- Malaria
- *M. pneumoniae* (primary atypical pneumonia)
- Multiple myeloma
- Raynaud's disease (severe)
- Systemic lupus erythematosus
- Trypanosomiasis

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Antibiotic use may interfere with or decrease antibody production.
- A high antibody titer may interfere with blood typing and crossmatching procedures.
- High titers may appear spontaneously in elderly patients and persist for many years.
- Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results. Specimens should always be transported to the laboratory as quickly as possible after collection. The specimen must clot in a 37°C water bath for 1 hr before separation. Refrigeration of the sample before serum separates from the RBCs may falsely decrease the titer.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of primary

atypical pneumonia and other viral/infectious diseases.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and respiratory systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent medications that can interfere with test results.
- ▶ Review the procedure with the patient. Inform the patient that multiple specimens may be required. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions (except antibiotics) unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.
- ▶ Inform the laboratory if the patient is receiving antibiotics.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume antibiotics as directed by the HCP.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Emphasize the need for the patient to return in 7 to 14 days for a convalescent blood sample. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include arterial/alveolar oxygen ratio, blood gases, chest x-ray, complete blood count, complete blood count WBC count, Coombs' antiglobulin, culture viral, ESR, gallium scan, infectious mononucleosis screen, lung perfusion scan, plethysmography, and pleural fluid analysis.
- ▶ Refer to the Immune and Respiratory System tables at the end of the book for related tests by body system.

Collagen Cross-Linked N-Telopeptide

SYNONYM/ACRONYM: NT_x.

SPECIMEN: Urine (2 mL) from a random specimen collected in a clean plastic container.

REFERENCE VALUE: (Method: Immunoassay)

Male	0–85 nmol bone collagen equivalents/mmol creatinine
Female (premenopausal)	14–76 nmol bone collagen equivalents/mmol creatinine

DESCRIPTION: Osteoporosis is the most common bone disease in the West. It is often called the “silent disease” because bone loss occurs without symptoms. The formation and maintenance of bone mass is dependent on a combination of factors that include genetics, nutrition, exercise, and hormone function. Normally, the rate of bone formation is equal to the rate of bone resorption. After midlife, the rate of bone loss begins to increase. Osteoporosis is more commonly identified in women than in men. Other risk factors include thin, small-framed body structure; family history of osteoporosis; diet low in calcium; white or Asian race; excessive use of alcohol; cigarette smoking; sedentary lifestyle; long-term use of corticosteroids, thyroid replacement medications, or antiepileptics; history of bulimia, anorexia nervosa, chronic liver disease, or malabsorption disorders; and postmenopausal state. Osteoporosis is a major consequence of menopause in women owing to the decline of estrogen production. Osteoporosis is rare in premenopausal women.

Estrogen replacement therapy (after menopause) is one strategy that has been commonly employed to prevent osteoporosis, although its exact protective mechanism is unknown. Results of some recently published studies indicate that there may be significant adverse side effects to estrogen replacement therapy; more research is needed to understand the long-term effects (positive and negative) of this therapy. Other treatments include raloxifene (selectively modulates estrogen receptors), calcitonin (interacts directly with osteoclasts), and bisphosphates (inhibit osteoclast-mediated bone resorption).

A noninvasive test to detect the presence of collagen cross-linked N-telopeptide (NT_x) is used to follow the progress of patients who have begun treatment for osteoporosis. NT_x is formed when collagenase acts on bone. Small NT_x fragments are excreted in the urine after bone resorption. A desirable response, 2 to 3 mo after therapy is initiated, is a 30% reduction in NT_x and a reduction of 50% below baseline by 12 mo.

INDICATIONS:

- Assist in the evaluation of osteoporosis
- Assist in the management and treatment of osteoporosis
- Monitor effects of estrogen replacement therapy

RESULT:**Increased in:**

- Hyperparathyroidism (*Imbalance in calcium and phosphorus that affects the rate of bone resorption*)
- Osteomalacia (*Increased bone turnover related to defective bone mineralization*)
- Osteoporosis (*Increased bone turnover*)
- Paget's disease (*Increased bone resorption; more calcium coming out of bone than being returned*)

Decreased in:

- Effective therapy for osteoporosis

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- NT_x levels are affected by urinary excretion, and values may be influenced by the presence of renal impairment or disease.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of osteoporosis and evaluation of therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's musculoskeletal and reproductive systems and results of previously

performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
- ▶ Instruct the patient to collect a second-void morning specimen as follows: (1) void and then drink a glass of water; (2) wait 30 min, and then try to void again.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
- ▶ *Dietary considerations:* Increased NT_x levels may be associated with osteoporosis. Nutritional therapy may be indicated for patients identified as being at high risk for developing osteoporosis. Educate the patient about the National Osteoporosis Foundation's guidelines regarding a regular regimen of weight-bearing exercises, limited

alcohol intake, avoidance of tobacco products, and adequate dietary intake of vitamin D (400 to 800 IU/d) and calcium (1200 to 1500 mg/d). Dietary calcium can be obtained in animal or plant sources. Milk and milk products, sardines, clams, oysters, salmon, rhubarb, spinach, beet greens, broccoli, kale, tofu, legumes, and fortified orange juice are high in calcium. Milk and milk products also contain vitamin D and lactose to assist in absorption. Cooked vegetables yield more absorbable calcium than raw vegetables. Patients should also be informed of the substances that can inhibit calcium absorption by irreversibly binding to some of the calcium and making it unavailable for absorption, such as oxalates, which naturally occur in some vegetables; phytic acid, found in some cereals; and excessive intake of insoluble dietary fiber. Excessive protein intake also can affect calcium absorption negatively, especially if it is combined with foods high in phosphorus. Vitamin D is synthesized by the skin and is available in fortified dairy foods and cod liver oil.

- ◆ Recognize anxiety related to test results, and be supportive of impaired activity related to lack of muscular control, perceived loss of independence,

and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the National Osteoporosis Foundation (www.nof.org).

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ALP, BMD, calcitonin, calcium, creatinine, creatinine clearance, osteocalcin, PTH, phosphorus, radiography bone, and vitamin D.
- ◆ Refer to the Musculoskeletal and Reproductive System tables at the end of the book for related tests by body system.

Colonoscopy

SYNONYM/ACRONYM: Full colonoscopy, lower endoscopy, lower panendoscopy.

AREA OF APPLICATION: Colon.

CONTRAST: Air.

DESCRIPTION: Colonoscopy allows inspection of the mucosa of the entire colon, ileocecal valve, and terminal ileum using a flexible

fiberoptic colonoscope inserted through the anus and advanced to the terminal ileum. The colonoscope is a multichannel

instrument that allows viewing of the gastrointestinal (GI) tract lining, insufflation of air, aspiration of fluid, obtaining of tissue biopsy samples, and passage of a laser beam for obliteration of tissue and control of bleeding. Mucosal surfaces of the lower GI tract are examined for ulcerations, polyps, chronic diarrhea, hemorrhagic sites, neoplasms, and strictures. During the procedure, tissue samples may be obtained for cytology, and some therapeutic procedures may be performed, such as excision of small tumors or polyps, coagulation of bleeding sites, and removal of foreign bodies.

INDICATIONS:

- Assess GI function in a patient with a personal or family history of colon cancer, polyps, or ulcerative colitis
- Confirm diagnosis of colon cancer and inflammatory bowel disease
- Detect Hirschsprung's disease and determine the areas affected by the disease
- Determine cause of lower GI disorders, especially when barium enema and proctosigmoidoscopy are inconclusive
- Determine source of rectal bleeding and perform hemostasis by coagulation
- Evaluate postsurgical status of colon resection
- Evaluate stools that show a positive occult blood test, lower GI bleeding, or change in bowel habits
- Follow up on previously diagnosed and treated colon cancer
- Investigate iron-deficiency anemia of unknown origin

- Reduce volvulus and intussusception in children
- Remove colon polyps
- Remove foreign bodies and sclerosing strictures by laser

RESULT:

Normal findings in:

- Normal intestinal mucosa with no abnormalities of structure, function, or mucosal surface in the colon or terminal ileum

Abnormal findings in:

- Benign lesions
- Bleeding sites
- Bowel distention
- Bowel infection or inflammation
- Colitis
- Colon cancer
- Crohn's disease
- Diverticula
- Foreign bodies
- Hemorrhoids
- Polyps
- Proctitis
- Tumors
- Vascular abnormalities

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with bleeding disorders or cardiac conditions
- Patients with bowel perforation, acute peritonitis, acute colitis, ischemic bowel necrosis, toxic colitis, recent bowel surgery, advanced pregnancy, severe cardiac or pulmonary disease, recent myocardial infarction, known or suspected pulmonary embolus, and large abdominal aortic or iliac aneurysm
- Patients who have had a colon anastomosis within the past 14 to 21 days, because an anastomosis may break down with gas insufflation

Factors that may impair clear imaging:

- Gas or feces in the GI tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Severe lower GI bleeding or the presence of feces, barium, blood, or blood clots, which can interfere with visualization
- Spasm of the colon, which can mimic the radiographic signs of cancer (Note: the use of IV glucagon minimizes spasm)
- Inability of the patient to tolerate introduction of or retention of barium, air, or both in the bowel

Other considerations:

- Complications of the procedure may include hemorrhage and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Bowel preparations that include laxatives or enemas should be avoided in pregnant patients or patients with inflammatory bowel disease, unless specifically directed by a health care provider (HCP).

- Consultation with a HCP should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the examination room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the colon.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Ensure that this procedure is performed before an upper GI study or barium swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Note intake of oral iron preparations within 1 wk before the procedure because these cause black, sticky feces that are difficult to remove with bowel preparation.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a GI lab, by a HCP, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Inform the patient that it is important that the bowel be cleaned thoroughly so that the physician can visualize the colon. Inform the patient that a laxative and cleansing enema may be needed the day before the procedure, with cleansing enemas on the morning of the procedure, depending on the institution's policy.
- ▶ Instruct the patient to remove all external metallic objects from the area to be examined.
- ▶ Instruct the patient to eat a low-residue diet for several days before the procedure and to consume only clear liquids the evening before the test. The patient should fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- ▶ Ensure that ordered laxatives were administered late in the afternoon of the day before the procedure.
- ▶ Assess for completion of bowel preparation according to the institution's procedure.
- ▶ Instruct the patient to remove all external metallic objects from the area to be examined.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate containers with the corresponding patient demographics, date, and time of collection.
- ▶ Obtain and record baseline vital signs.
- ▶ An IV line may be started to allow infusion of a sedative or IV fluids.
- ▶ Administer medications, as ordered, to reduce discomfort and to promote relaxation and sedation.
- ▶ Place the patient on an examination table in the left lateral decubitus position and drape with the buttocks exposed.
- ▶ The HCP performs a visual inspection of the perianal area and a digital rectal examination.
- ▶ Instruct the patient to bear down as if having a bowel movement as the fiberoptic tube is inserted through the rectum.
- ▶ The scope is advanced through the sigmoid. The patient's position is changed to supine to facilitate passage into the transverse colon. Air is insufflated through the tube during passage to aid in visualization.
- ▶ Instruct the patient to take deep breaths to aid in movement of the scope downward through the ascending colon to the cecum and into the terminal portion of the ileum.▶

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid and medication restrictions, and pretesting preparations for at least 8 hr prior to the procedure.

- ▶ Air is insufflated to distend the GI tract, as needed. Biopsies, cultures, or any endoscopic surgery is performed.
- ▶ Foreign bodies or polyps are removed and placed in appropriate specimen containers, labeled, and sent to the laboratory.
- ▶ Photographs are obtained for future reference.
- ▶ At the end of the procedure, excess air and secretions are aspirated through the scope, and the colonoscope is removed.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
 - ▶ Monitor the patient for signs of respiratory depression.
 - ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, or as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
 - ▶ Observe the patient until the effects of the sedation have worn off.
 - ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
 - ▶ Monitor for any rectal bleeding. Instruct the patient to expect slight rectal bleeding for 2 days after removal of polyps or biopsy specimens, but that an increasing amount of bleeding or sustained bleeding should be reported to the HCP immediately.
 - ▶ Observe the patient for indications of chest pain, abdominal pain or tenderness, or breathing problems. If these symptoms are present or increase in frequency or severity, the change should be reported to a HCP immediately.
- ▶ Inform the patient that belching, bloating, or flatulence is the result of air insufflation.
 - ▶ Emphasize that any severe pain, fever, difficulty breathing, or GI bleeding must be reported to the HCP immediately.
 - ▶ Encourage the patient to drink several glasses of water to help replace fluids lost during the preparation for the test.
 - ▶ Carefully monitor the patient for fatigue and fluid and electrolyte imbalance.
 - ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
 - ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include barium enema, biopsy intestinal, capsule endoscopy, carcinoembryonic and cancer antigens, CT abdomen, CT colonoscopy, fecal analysis, KUB, MRI abdomen, and proctosigmoidoscopy.
- ▶ Refer to the Gastrointestinal System table in the back of the book for related tests by body system.

Color Perception Test

SYNONYM/ACRONYM: Color blindness test, Ishihara color perception test, Ishihara pseudoisochromatic plate test.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: Defects in color perception can be hereditary or acquired. The congenital defect for color blindness is carried by the female, who is generally unaffected, and is expressed dominantly in males. Color blindness occurs in 8% of males and 0.4% of females. It may be partial or complete. The partial form is the hereditary form, and in the majority of patients the color deficiency is in the red-green area of the spectrum. Acquired color blindness may occur as a result of diseases of the retina or optic nerve. Color perception tests are performed to determine the acuity of color discrimination. The most common test uses pseudoisochromatic plates with numbers or letters buried in a maze of dots. Misreading the numbers or letters indicates a color perception deficiency and may indicate color blindness, a genetic dysfunction, or retinal pathology.

INDICATIONS:

- Detect deficiencies in color perception
- Evaluate because of family history of color visual defects
- Investigate suspected retinal pathology affecting the cones

RESULT:

Normal findings in:

- Normal visual color discrimination; no difficulty in identification of color combinations

Abnormal findings in:

- Identification of some but not all colors

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Inability of the patient to read
- Poor visual acuity or poor lighting
- Failure of the patient to wear corrective lenses (glasses or contact lenses)
- Damaged or discolored test plates

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure detects color vision impairment.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's known or suspected vision loss,

changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.

- ◆ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Ask the patient if he or she wears corrective lenses; also inquire about the importance of color discrimination in his or her work, as applicable. Address concerns about pain and explain that no discomfort will be experienced during the test. Inform the patient that a health care provider (HCP) performs the test in a quiet, darkened room, and that to evaluate both eyes, the test can take 5 to 15 or up to 30 min, depending on the complexity of testing required.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ◆ Instruct the patient to cooperate fully and to follow directions.
- ◆ Seat the patient comfortably. Occlude one eye and hold test booklet 12 to 14 in. in front of the exposed eye.
- ◆ Ask the patient to identify the numbers or letters buried in the

maze of dots or to trace the objects with a hand-held pointed object.

- ◆ Repeat on the other eye.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Recognize anxiety related to test results and be supportive of impaired activity related to color vision loss. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide contact information regarding vision aids for people with impaired color perception, if desired—ABLEDATA (sponsored by the National Institute on Disability and Rehabilitation Research [NIDRR], available at www.abledata.com).
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include refraction and slit-lamp biomicroscopy.
- ◆ Refer to the Ocular System table in the back of the book for related tests by body system.

Colposcopy

SYNONYM/ACRONYM: Endometrial biopsy, cervical biopsy.

AREA OF APPLICATION: Vagina and cervix.

CONTRAST: None.

DESCRIPTION: In this procedure, the vagina and cervix are viewed using a colposcope, a special binocular microscope and light system that magnifies the mucosal surfaces. Colposcopy is usually performed after suspicious Papanicolaou (Pap) test results or when suspected lesions cannot be visualized fully by the naked eye. The procedure is useful for identifying areas of cellular dysplasia and diagnosing cervical cancer because it provides the best view of the suspicious lesion, ensuring that the most representative area of the lesion is obtained for cytological analysis to confirm malignant changes. Colposcopy is also valuable for assessing women with a history of exposure to diethylstilbestrol (DES) in utero. The goal is to identify precursor changes in cervical tissue before the changes advance from benign or atypical cells to cervical cancer. Photographs (cervicography) can also be taken of the cervix.

INDICATIONS:

- Evaluate the cervix after abnormal Pap smear
- Evaluate vaginal lesions
- Localize the area from which cervical biopsy samples should be obtained because such areas may not be visible to the naked eye
- Monitor conservatively treated cervical intraepithelial neoplasia
- Monitor women whose mothers took DES during pregnancy

RESULT:

Normal findings in:

- Normal appearance of the vagina and cervix
- No abnormal cells or tissues

Abnormal findings in:

- Atrophic changes
- Cervical erosion
- Cervical intraepithelial neoplasia
- Infection
- Inflammation
- Invasive carcinoma
- Leukoplakia
- Papilloma, including condyloma

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Patients with cardiac conditions
- Patients with bleeding disorders, especially if cervical biopsy specimens are to be obtained
- Women who are currently menstruating

Factors that may impair clear imaging:

- Inadequate cleansing of the cervix of secretions and medications
- Scarring of the cervix
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Severe bleeding or the presence of feces, blood, or blood clots, which can interfere with visualization

Other considerations:

- Complications of the procedure may include hemorrhage and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the uterus and cervix.
- ▶ Obtain a history of the patient's complaints including a list of known allergens, especially allergies or sensitivities to latex, iodine, or anesthetics.
- ▶ Obtain a history of results of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.

- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed by a health care provider (HCP), with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain to the patient that if a biopsy is performed, she may feel menstrual-like cramping during the procedure and experience a minimal amount of bleeding.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ **Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.**

INTRATEST:

- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate containers with the corresponding patient demographics, date, and time of collection.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Obtain and record baseline vital signs.
- ▶ An IV line may be started to allow infusion of a sedative or IV fluids.
- ▶ Administer medications, as ordered, to reduce discomfort and to promote relaxation and sedation.
- ▶ Place the patient in the lithotomy position on the examining table and drape her. Cleanse the external genitalia with an antiseptic solution.
- ▶ If a Pap smear is performed, the vaginal speculum is inserted, using water as a lubricant.

- ▶ The cervix is swabbed with 3% acetic acid to remove mucus or any cream medication and to improve the contrast between tissue types. The scope is positioned at the speculum and is focused on the cervix. The area is examined carefully, using light and magnification. Photographs can be taken for future reference.
- ▶ Tissues that appear abnormal or atypical undergo biopsy using a forceps inserted through the speculum. Bleeding, which is common after cervical biopsy, may be controlled by cautery, suturing, or application of silver nitrate or ferric subsulfate (Monsel's solution) to the site.
- ▶ The vagina is rinsed with sterile saline or water to remove the acetic acid and prevent burning after the procedure. If bleeding persists, a tampon may be inserted after removal of the speculum.
- ▶ Biopsy samples are placed in appropriately labeled containers with special preservative solution, and promptly transported to the laboratory.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Monitor the patient for signs of respiratory depression.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe the patient until the effects of the sedation, if ordered, have worn off.
- ▶ Instruct the patient to remove the vaginal tampon, if inserted, within 8 to 24 hr; after that time, the patient should wear pads if there is bleeding or drainage.

- ▶ If a biopsy was performed, inform the patient that a discharge may persist for a few days to a few weeks.
- ▶ Advise the patient to avoid strenuous exercise 8 to 24 hr after the procedure, and to avoid douching and intercourse for about 2 wk or as directed by the HCP.
- ▶ Monitor for any bleeding.
- ▶ Instruct the patient to expect slight bleeding for 2 days after removal of biopsy specimens, but emphasize that persistent vaginal bleeding or abnormal vaginal discharge, an increasing amount of bleeding, abdominal pain, and fever must be reported to the HCP immediately.
- ▶ Observe the patient for indications of chest pain, abdominal pain or tenderness, or breathing problems. If symptoms are present or increase in frequency or severity, the change should be reported to the HCP immediately.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy cervical, CT abdomen, culture viral, MRI abdomen, PAP smear, and US pelvis.
- ▶ Refer to the Reproductive System table at the back of the book for related tests by body system.

Complement C3 and Complement C4

SYNONYM/ACRONYM: C3 and C4.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Nephelometry)

C3

Age	Conventional Units	SI Units (Conventional Units × 10)
Newborn	57–116 mg/dL	570–1160 mg/L
6 mo–adult	74–166 mg/dL	740–1660 mg/L
Adult	83–177 mg/dL	830–1770 mg/L

C4

Age	Conventional Units	SI Units (Conventional Units × 10)
Newborn	10–31 mg/dL	100–310 mg/L
6 mo–6 yr	15–52 mg/dL	150–520 mg/L
7–12 yr	19–40 mg/dL	190–400 mg/L
13–15 yr	19–57 mg/dL	190–570 mg/L
16–18 yr	19–42 mg/dL	190–420 mg/L
Adult	12–36 mg/dL	120–360 mg/L

DESCRIPTION: Complement proteins act as enzymes that aid in the immunological and inflammatory response. The complement system is an important mechanism for the destruction and removal of foreign materials. Serum complement levels are used to detect autoimmune diseases. C3 and C4 are the most frequently assayed complement proteins, along with total complement.

Circulating C3 is synthesized in the liver and comprises 70% of the complement system, but cells in other tissues can also produce C3. C3 is an essential

activating protein in the classic and alternate complement cascades. It is decreased in patients with immunological diseases, in whom it is consumed at an increased rate. C4 is produced primarily in the liver but can also be produced by monocytes, fibroblasts, and macrophages. C4 participates in the classic complement pathway.

INDICATIONS:

- Detect genetic deficiencies
- Evaluate immunological diseases

RESULT:

Normal C4 and decreased C3

Acute glomerulonephritis, membranous glomerulonephritis, immune complex diseases, SLE, C3 deficiency

Decreased C4 and normal C3

Immune complex diseases, cryoglobulinemia, C4 deficiency, hereditary angioedema

Decreased C4 and decreased C3

Immune complex diseases

Increased in:
Response to sudden increased demand.

- C3 and C4
Acute-phase reactions
- C3
Amyloidosis
Cancer
Diabetes
Myocardial infarction
Pneumococcal pneumonia
Pregnancy
Rheumatic disease
Thyroiditis
Viral hepatitis
- C4
Certain malignancies

Juvenile dermatomyositis
Meningitis (bacterial, viral)
Pneumonia
Streptococcal or staphylococcal sepsis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase C3 levels include cimetidine and cyclophosphamide.
- Drugs that may decrease C3 levels include danazol and phenytoin.
- Drugs that may increase C4 levels include cimetidine, cyclophosphamide, and danazol.
- Drugs that may decrease C4 levels include dextran and penicillamine.

Decreased in:
Related to overconsumption during immune response.

- C3 and C4
Hereditary deficiency (*Insufficient production*)
Liver disease (*Insufficient production related to damaged liver cells*)
Systemic lupus erythematosus (SLE)
- C3
Chronic infection (bacterial, parasitic, viral)
Post–membranoproliferative glomerulonephritis
Post–streptococcal infection
Rheumatic arthritis
- C4
Angioedema (*hereditary and acquired*)
Autoimmune hemolytic anemia
Autoimmune thyroiditis
Cryoglobulinemia
Glomerulonephritis

NURSING IMPLICATIONS AND PROCEDURE
PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of immunological diseases in which complement is consumed at an increased rate or to detect inborn deficiency.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune system and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture

site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include anticardiolipin antibody, ANA, complement total, cryoglobulin, and ESR.

- Refer to the Immune System table at the end of the book for related tests by body system.

Complement, Total

SYNONYM/ACRONYM: Total hemolytic complement, CH₅₀, CH₁₀₀.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Quantitative hemolysis)

Conventional Units	SI Units (Conventional Units × 1)
40–100 CH ₅₀ units/mL	40–100 CH ₅₀ kU/L

DESCRIPTION: The complement system comprises proteins that become activated and interact in a sequential cascade. The complement system is an important part of the body's natural defense against allergic and immune reactions. It is activated by plasmin and is interrelated with the coagulation and fibrinolytic systems. Activation of the complement system results in cell lysis, release of histamine, chemotaxis of white blood cells, increased vascular permeability, and contraction of smooth muscle. The activation of this system can sometimes occur with uncontrolled self-destructive effects on the body. In the serum complement assay, a patient's serum is mixed with sheep red blood cells coated with antibodies. If complement is present in sufficient quantities, 50% of the red blood cells are lysed. Lower amounts of lysed cells are associated with decreased complement levels.

INDICATIONS:

- Assist in the diagnosis of hereditary angioedema
- Evaluate complement activity in autoimmune disorders
- Evaluate and monitor therapy for systemic lupus erythematosus (SLE)
- Screen for complement deficiency

RESULT:

Increased in:

- Acute-phase immune response (**Response to sudden increased demand**)

Decreased in:

- Autoimmune diseases (**Related to continuous demand**)
- Autoimmune hemolytic anemia (**Related to consumption during hemolytic process**)

- Burns (**Increased consumption from initiation of complement cascade**)
- Cryoglobulinemia (**Related to increased consumption**)
- Hereditary deficiency (**Insufficient production**)
- Infections (**Bacterial, parasitic, viral; increased consumption during immune response**)
- Liver disease (**Related to decreased production by damaged liver cells**)
- Malignancy (**Related to consumption during cellular immune response**)
- Membranous glomerulonephritis (**Related to consumption during cellular immune response**)
- Rheumatoid arthritis (**Related to consumption during immune response**)
- SLE (**Related to consumption during immune response**)
- Trauma (**Related to consumption during immune response**)
- Vasculitis (**Related to consumption during cellular immune response**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase total complement levels include cyclophosphamide and danazol.
- Specimen should not remain at room temperature longer than 1 hr.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate immune diseases related to complement activity and follow up on a patient's response to therapy.
- ♦ Obtain a history of the patient's complaints, including a list of

known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's immune system and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient

demographics, date, and time of collection. Perform a venipuncture.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibody anticytoplasmic neutrophilic, ANA, Coomb's antiglobulin, complement C3 and C4, cryoglobulin, ESR, G6PD, Ham's test, osmotic fragility, PK, RF.
- ▶ Refer to the Immune System table at the end of the book for related tests by body system.

Complete Blood Count

SYNONYM/ACRONYM: CBC.

SPECIMEN: Whole blood from one full lavender-top (EDTA) tube or Microtainer. Whole blood from a green-top (lithium or sodium heparin) tube may be submitted, but the following automated values may not be reported: white blood cell (WBC) count, WBC differential, platelet count, and mean platelet volume.

REFERENCE VALUE: (Method: Automated, computerized multichannel analyzers that sort and size cells on the basis of changes in either electrical impedance or light pulses as the cells pass in front of a laser. Many of these analyzers are capable of determining a five-part WBC differential.) This battery of tests includes hemoglobin, hematocrit, red blood cell (RBC) count, RBC morphology, RBC indices, RBC distribution width index (RDW), platelet count, platelet size, WBC count, and WBC differential. The five-part automated WBC differential identifies and enumerates neutrophils, lymphocytes, monocytes, eosinophils, and basophils.

Hemoglobin (See “Complete Blood Count, Hemoglobin” monograph for more detailed information)

Age	Conventional Units	SI Units (Conventional Units × 10)
Cord blood	13.5–20.5 g/dL	135–205 mmol/L
2 wk	13.4–19.8 g/dL	134–198 mmol/L
1 mo	10.7–17.1 g/dL	107–171 mmol/L
6 mo	11.1–14.4 g/dL	111–144 mmol/L
1 yr	11.3–14.1 g/dL	113–141 mmol/L
9–14 yr	12.0–14.4 g/dL	120–144 mmol/L
Adult		
<i>Male</i>	13.2–17.3 g/dL	132–173 mmol/L
<i>Female</i>	11.7–15.5 g/dL	117–155 mmol/L
Older adult (65–74 y)		
<i>Male</i>	12.6–17.4 g/dL	126–174 mmol/L
<i>Female</i>	11.7–16.1 g/dL	117–161 mmol/L

Hematocrit (See “Complete Blood Count, Hematocrit” monograph for more detailed information)

Age	Conventional Units (%)	SI Units (Conventional Units × 0.01)
Cord blood	47–57	0.47–0.57
1 d	51–65	0.51–0.65
2 wk	47–57	0.47–0.57
1 mo	38–52	0.38–0.52
6 mo	35–41	0.35–0.41
1 yr	37–41	0.37–0.41
10 yr	36–42	0.36–0.42
Adult		
<i>Male</i>	43–49	0.43–0.49
<i>Female</i>	38–44	0.38–0.44

White Blood Cell Count and Differential (See "White Blood Cell Count and Cell Differential" monograph for more detailed information)

Age	Conventional Units WBC \times $10^3/\text{mm}^3$ ^a	Neutrophils		Lymphocytes		Monocytes		Eosinophils		Basophils	
		Total Neutrophils (Absolute) and %	Bands (Absolute) and %	Segments (Absolute) and %	(Absolute) and %	(Absolute) and %	(Absolute) and %	(Absolute) and %	(Absolute) and %	(Absolute) and %	(Absolute) and %
Birth	9.0–30.0	(5.5–18.3) 61%	(0.8–2.7) 9.1%	(4.7–15.6) 52%	(2.8–9.3) 31%	(0.5–1.7) 5.8%	(0.02–0.7) 2.2%	(0.1–0.2) 0.6%			
1 to 23 mo	6.0–17.5	(1.9–5.4) 31%	(0.2–0.5) 3.1%	(1.7–4.9) 28%	(3.7–10.7) 61%	(0.3–0.8) 4.8%	(0.2–0.5) 2.6%	(0–0.1) 0.5%			
2 to 10 yr	4.5–13.5	(2.4–7.3) 54%	(0.1–0.4) 3.0%	(2.3–6.9) 51%	(1.7–5.1) 38%	(0.2–0.6) 4.3%	(0.1–0.3) 2.4%	(0–0.1) 0.5%			
11 yr to Adult	4.5–11.0	(2.7–6.5) 59%	(0.1–0.3) 3.0%	(2.5–6.2) 56%	(1.5–3.7) 34%	(0.2–0.4) 4.0%	(0.05–0.5) 2.7%	(0–0.1) 0.5%			

^aSI Units (Conventional Units $\times 1 \times 10^9/\text{L}$ or WBC $\times 1000/\text{mm}^3$)

Red Blood Cell Count (See "Complete Blood Count, Red Blood Cell Count" monograph for more detailed information)

Age	Conventional Units	SI Units (Conventional Units × 1)
Cord blood	4.14–4.69 × 10 ⁶ cells/mm ³	4.14–4.69 × 10 ¹² cells/L
1 d	5.33–5.47 × 10 ⁶ cells/mm ³	5.33–5.47 × 10 ¹² cells/L
2 wk	4.32–4.98 × 10 ⁶ cells/mm ³	4.32–4.98 × 10 ¹² cells/L
1 mo	3.75–4.95 × 10 ⁶ cells/mm ³	3.75–4.95 × 10 ¹² cells/L
6 mo	3.71–4.25 × 10 ⁶ cells/mm ³	3.71–4.25 × 10 ¹² cells/L
1 yr	4.40–4.48 × 10 ⁶ cells/mm ³	4.40–4.48 × 10 ¹² cells/L
10 yr	4.75–4.85 × 10 ⁶ cells/mm ³	4.75–4.85 × 10 ¹² cells/L
Adult		
<i>Male</i>	4.71–5.14 × 10 ⁶ cells/mm ³	4.71–5.14 × 10 ¹² cells/L
<i>Female</i>	4.20–4.87 × 10 ⁶ cells/mm ³	4.20–4.87 × 10 ¹² cells/L

Red Blood Cell Indices (See "Complete Blood Count, Red Blood Cell Indices" monograph for more detailed information)

Age	MCV* (fl)	MCH (pg/cell)	MCHC (g/dL)	RDW
Cord blood	107–119	35–39	32–34	14.9–18.7
1 d	104–116	35–39	32–34	14.9–18.7
2 wk	95–117	29–35	28–32	14.9–18.7
1 mo	93–115	29–35	28–34	14.9–18.7
6 mo	82–100	24–30	28–32	14.9–18.7
1 y	81–95	25–29	29–31	11.6–14.8
10 y	75–87	25–31	33–35	11.6–14.8
Adult				
<i>Male</i>	85–95	28–32	33–35	11.6–14.8
<i>Female</i>	85–95	28–32	33–35	11.6–14.8

*MCV = mean corpuscular volume; MCH = mean corpuscular hemoglobin; MCHC = mean corpuscular hemoglobin concentration; RDW = RBC distribution width index.

Red Blood Cell Morphology (See "Complete Blood Count, Red Blood Cell Morphology and Inclusions" monograph for more detailed information)

Morphology	Within Normal Limits				
	1+	2+	3+	4+	
	<i>Size</i>				
Anisocytosis	0–5+	5–10	10–20	20–50	Greater than 50
Macrocytes	0–5+	5–10	10–20	20–50	Greater than 50
Microcytes	0–5+	5–10	10–20	20–50	Greater than 50
	<i>Shape</i>				
Poikilocytes	0–2+	3–10	10–20	20–50	Greater than 50
Burr cells	0–2+	3–10	10–20	20–50	Greater than 50
Acanthocytes	Less than 1+	2–5	5–10	10–20	Greater than 20
Schistocytes	Less than 1+	2–5	5–10	10–20	Greater than 20
Dacryocytes (teardrop cells)	0–2+	2–5	5–10	10–20	Greater than 20

(table continues on page 364)

Morphology	Within Normal Limits	1+	2+	3+	4+
	Codocytes (target cells)	0–2+	2–10	10–20	20–50
Spherocytes	0–2+	2–10	10–20	20–50	Greater than 50
Ovalocytes	0–2+	2–10	10–20	20–50	Greater than 50
Stomatocytes	0–2+	2–10	10–20	20–50	Greater than 50
Drepanocytes (sickle cells)	Absent	Reported as present or absent			
Helmet cells	Absent	Reported as present or absent			
Agglutination	Absent	Reported as present or absent			
Rouleaux	Absent	Reported as present or absent			
<i>Hemoglobin Content</i>					
Hypochromia	0–2+	3–10	10–50	50–75	Greater than 75
Polychromasia					
<i>Adult</i>	Less than 1+	2–5	5–10	10–20	Greater than 20
<i>Newborn</i>	1–6+	7–15	15–20	20–50	Greater than 50

Red Blood Cell Inclusions (See “Complete Blood Count, Red Blood Cell Morphology and Inclusions” monograph for more detailed information)

Inclusions	Within Normal Limits	1+	2+	3+	4+
	Cabot's rings	Absent	Reported as present or absent		
Basophilic stippling	0–1+	1–5	5–10	10–20	Greater than 20
Howell-Jolly bodies	Absent	1–2	3–5	5–10	Greater than 10
Heinz bodies	Absent	Reported as present or absent			
Hemoglobin C crystals	Absent	Reported as present or absent			
Pappenheimer bodies	Absent	Reported as present or absent			
Intracellular parasites (e.g., <i>Plasmodium</i> , <i>Babesia</i> , trypanosomes)	Absent	Reported as present or absent			

Platelet Count (See “Complete Blood Count, Platelet Count” monograph for more detailed information)

Age	Conventional Units	SI Units (Conventional Units × 1)	MPV (fl)
1–5 yr	217,000–497,000/mm ³	217–497 × 10 ⁹ /L	7.2–10.0
Adult	150,000–450,000/mm ³	150–450 × 10 ⁹ /L	7.0–10.2

DESCRIPTION: A complete blood count (CBC) is a group of tests used for basic screening purposes. It is probably the most widely ordered laboratory test. Results provide the enumeration of the cellular elements of the blood, measurement of RBC indices, and determination of cell morphology by automation and evaluation of stained smears. The results can provide valuable diagnostic information regarding the overall health of the patient and the patient's response to disease and treatment. Detailed information is found in monographs titled "Complete Blood Count, Hemoglobin," "Complete Blood Count, Hematocrit," "Complete Blood Count, Red Blood Cell Indices," "Complete Blood Count, Red Blood Cell Morphology and Inclusions," "Complete Blood Count, Red Blood Cell Count," "Complete Blood Count, Platelet Count," and "Complete Blood Count, White Blood Cell Count and Cell Differential."

INDICATIONS:

- Detect hematologic disorder, neoplasm, leukemia, or immunologic abnormality
- Determine the presence of hereditary hematologic abnormality
- Evaluate known or suspected anemia and related treatment
- Monitor blood loss and response to blood replacement
- Monitor the effects of physical or emotional stress
- Monitor fluid imbalances or treatment for fluid imbalances
- Monitor hematologic status during pregnancy
- Monitor progression of nonhematologic disorders, such as chronic obstructive pulmonary disease,

malabsorption syndromes, cancer, and renal disease

- Monitor response to chemotherapy and evaluate undesired reactions to drugs that may cause blood dyscrasias
- Provide screening as part of a general physical examination, especially on admission to a health care facility or before surgery

RESULT: See monographs titled "Complete Blood Count, Hemoglobin," "Complete Blood Count, Hematocrit," "Complete Blood Count, RBC Indices," "Complete Blood Count, RBC Morphology and Inclusions," "Complete Blood Count, RBC Count," "Complete Blood Count, Platelet Count," and "Complete Blood Count, WBC Count and Differential."

Increased in:

See above-listed monographs.

Decreased in:

See above-listed monographs.

CRITICAL VALUES:

Hemoglobin:

- Less than 6 g/dL
- Greater than 18 g/dL

Hematocrit:

- Less than 18%
- Greater than 54%

WBC count (on admission):

- Less than 2500/mm³
- Greater than 30,000/mm³

Platelet count:

- Less than 20,000/mm³
- Greater than 1,000,000/mm³

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

The presence of abnormal cells, other morphologic characteristics, or cellular inclusions may signify a potentially life-threatening or serious

health condition and should be investigated. Examples are the presence of sickle cells, moderate numbers of spherocytes, marked schistocytosis, oval macrocytes, basophilic stippling, eosinophil count greater than 10%, monocytosis greater than 15%, nucleated RBCs (if patient is not an infant), malarial organisms, hypersegmented neutrophils, agranular neutrophils, blasts or other immature cells, Auer rods, Döhle bodies, marked toxic granulation, or plasma cells.

INTERFERING FACTORS:

- Failure to fill the tube sufficiently (less than three-fourths full) may yield inadequate sample volume for automated analyzers and may be a reason for specimen rejection.
- Hemolyzed or clotted specimens should be rejected for analysis.
- Elevated serum glucose or sodium levels may produce elevated mean corpuscular volume values because of swelling of erythrocytes.
- Recent transfusion history should be considered when evaluating the CBC.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate numerous conditions involving red blood cells, white blood cells, and platelets. The test is also used to indicate inflammation, infection, and response to chemotherapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal, hematopoietic, immune, and respiratory systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. An EDTA Microtainer sample may be obtained from infants, children, and adults for whom venipuncture may not be feasible. The specimen should be analyzed within 6 hr when stored at room temperature or within 24 hr if stored at refrigerated temperature. If it is anticipated that the specimen will not be analyzed within 4 to 6 hr, two blood smears should be made immediately after the venipuncture and submitted with the blood sample. Smears made from specimens older than 6 hr will contain an unacceptable number of misleading artifactual abnormalities of the RBCs, such as echinocytes and spherocytes, as well as necrobiotic WBCs.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Instruct patients to consume a variety of foods within the basic food groups, maintain a healthy weight, be physically active, limit salt intake, limit alcohol intake, and avoid use of tobacco.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in

relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include alveolar arterial ratio, biopsy bone marrow, blood gases, blood groups and antibodies, erythropoietin, ferritin, complete blood count hematocrit, complete blood count hemoglobin, iron/TIBC, lead, complete blood count platelet count, pulse oximetry, complete blood count RBC count, complete blood count RBC indices, complete blood count RBC morphology, reticulocyte count, and complete blood count WBC count and cell differential.
- ▶ Refer to the Gastrointestinal, Genitourinary, Hematopoietic, Immune, and Respiratory System tables at the end of the book for related tests by body system.

Complete Blood Count, Hematocrit

SYNONYM/ACRONYM: Packed cell volume (PCV), Hct.

SPECIMEN: Whole blood from one full lavender-top (EDTA) tube, Microtainer, or capillary. Whole blood from a green-top (lithium or sodium heparin) tube may also be submitted.

REFERENCE VALUE: (Method: Automated, computerized, multichannel analyzers)

Age	SI Units	
	Conventional Units	Conventional Units × 0.01
Cord blood	47–57	0.47–0.57
1 d	51–65	0.51–0.65
2 wk	47–57	0.47–0.57
1 mo	38–52	0.38–0.52
6 mo	35–41	0.35–0.41
1 yr	37–41	0.37–0.41
10 yr	36–42	0.36–0.42
Adult		
<i>Male</i>	43–49	0.43–0.49
<i>Female</i>	38–44	0.38–0.44

DESCRIPTION: Blood consists of a fluid portion (plasma) and a solid portion that includes red blood cells (RBCs), white blood cells, and platelets. The hematocrit, or packed cell volume, is the percentage of RBCs in a volume of whole blood. For example, a hematocrit (Hct) of 45% means that a 100-mL sample of blood contains 45 mL of packed RBCs. Although the Hct depends primarily on the number of RBCs, the average size of the RBCs plays a role. Conditions that cause the RBCs to swell, such as when the serum sodium concentration is elevated, may increase the Hct level.

Hct level is included in the complete blood count (CBC) and is generally tested together with hemoglobin (Hgb). These levels parallel each other and are the best determinant of the degree of anemia or polycythemia.

Polycythemia is a term used in conjunction with conditions resulting from an abnormal increase in Hgb, Hct, and RBC count. *Anemia* is a term associated with conditions resulting from an abnormal decrease in Hgb, Hct, and RBC count. Results of the Hgb, Hct, and RBC count should be evaluated simultaneously because the same underlying conditions affect this triad of tests similarly. The RBC count multiplied by 3 should approximate the Hgb concentration. The Hct should be within three times the Hgb if the RBC population is normal in size and shape. The Hct plus 6 should approximate the first two figures of the RBC count within 3 (e.g., Hct is 40%; therefore $40 + 6 = 46$, and the RBC count should be 4.6 or in the range of 4.3 to 4.9). There are some

cultural variations in Hgb and Hct (H&H) values. After the first decade of life, the mean Hgb in African Americans is 0.5 to 1.0 g lower than in whites. Mexican Americans and Asian Americans have higher H&H values than whites.

INDICATIONS:

- Detect hematological disorder, neoplasm, or immunological abnormality
- Determine the presence of hereditary hematological abnormality
- Evaluate known or suspected anemia and related treatment, in combination with Hgb
- Monitor blood loss and response to blood replacement, in combination with Hgb
- Monitor the effects of physical or emotional stress on the patient
- Monitor fluid imbalances or their treatment
- Monitor hematological status during pregnancy, in combination with Hgb
- Monitor the progression of non-hematological disorders such as chronic obstructive pulmonary disease, malabsorption syndromes, cancer, and renal disease
- Monitor response to drugs or chemotherapy, and evaluate undesired reactions to drugs that may cause blood dyscrasias
- Provide screening as part of a CBC count in a general physical examination, especially upon admission to a health care facility or before surgery

RESULT:

Increased in:

- Burns (**Related to dehydration; total blood volume is decreased but RBC count remains the same**)
- Congestive heart failure (**When the underlying cause is anemia,**

the body will respond by increasing production of RBC; with a responding increase in Hct)

- COPD (*Related to chronic hypoxia that stimulates production of RBC and a corresponding increase in Hct*)
- Dehydration (*Total blood volume is decreased but RBC count remains the same*)
- Erythrocytosis (*Total blood volume remains the same but RBC count is increased*)
- Hemoconcentration (*Same effect as seen in dehydration*)
- High altitudes (*Related to hypoxia that stimulates production of RBC and therefore increases Hct*)
- Polycythemia (*Abnormal bone marrow response resulting in overproduction of RBC*)
- Shock

Decreased in:

- Anemia (*Overall decrease in RBC and corresponding decrease in Hct*)
- Blood loss (acute and chronic) (*Overall decrease in RBC and corresponding decrease in Hct*)
- Bone marrow hyperplasia (*Bone marrow failure that results in decreased RBC production*)
- Chronic disease (*Anemia is often associated with chronic disease*)
- Hemolytic disorders (*Reduced RBC survival with corresponding decrease in Hct*)
- Hemorrhage (acute and chronic) (*Related to loss of RBC that exceeds rate of production*)
- Fluid retention (*Dilutional effect of increased blood volume while RBC count remains stable*)
- Nutritional deficit (*Anemia related to dietary deficiency in iron, vitamins, folate needed to produce sufficient RBC;*

decreased RBC count with corresponding decrease in Hct)

- Pregnancy (*Related to anemia*)
- Splenomegaly (*Total blood volume remains the same but spleen retains RBCs and Hct reflects decreased RBC count*)

CRITICAL VALUES:



Less than 18%

Greater than 54%

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

Low Hct leads to anemia. Anemia can be caused by blood loss, decreased blood cell production, increased blood cell destruction, and hemodilution. Causes of blood loss include menstrual excess or frequency, gastrointestinal bleeding, inflammatory bowel disease, and hematuria. Decreased blood cell production can be caused by folic acid deficiency, vitamin B₁₂ deficiency, iron deficiency, and chronic disease. Increased blood cell destruction can be caused by a hemolytic reaction, chemical reaction, medication reaction, and sickle cell disease. Hemodilution can be caused by congestive heart failure, renal failure, polydipsia, and overhydration. Symptoms of anemia (due to these causes) include anxiety, dyspnea, edema, hypertension, hypotension, hypoxia, jugular venous distention, fatigue, pallor, rales, restlessness, and weakness. Treatment of anemia depends on the cause.

High Hct leads to polycythemia. Polycythemia can be caused by dehydration, decreased oxygen levels in the body, and an overproduction of RBCs by the bone marrow. Dehydration from diuretic use, vomiting, diarrhea, excessive sweating, severe burns, or decreased fluid intake decreases the plasma component of whole blood, thereby

increasing the ratio of RBCs to plasma, and leads to a higher than normal Hct. Causes of decreased oxygen include smoking, exposure to carbon monoxide, high altitude, and chronic lung disease, which leads to a mild hemoconcentration of blood in the body to carry more oxygen to the body's tissues. An overproduction of RBCs by the bone marrow leads to polycythemia vera, which is a rare chronic myeloproliferative disorder that leads to a severe hemoconcentration of blood. Severe hemoconcentration can lead to thrombosis (spontaneous blood clotting). Symptoms of hemoconcentration include decreased pulse pressure and volume, loss of skin turgor, dry mucous membranes, headaches, hepatomegaly, low central venous pressure, orthostatic hypotension, pruritis (especially after a hot bath), splenomegaly, tachycardia, thirst, tinnitus, vertigo, and weakness. Treatment of polycythemia depends on the cause. Possible interventions for hemoconcentration due to dehydration include intravenous fluids and discontinuance of diuretics if they are believed to be contributing to critically elevated Hct. Polycythemia due to decreased oxygen states can be treated by removal of the offending substance, such as smoke or carbon monoxide. Treatment includes oxygen therapy in cases of smoke inhalation, carbon monoxide poisoning, and desaturating chronic lung disease. Symptoms of polycythemic overload crisis include signs of thrombosis, pain and redness in the extremities, facial flushing, and irritability. Possible interventions for hemoconcentration due to polycythemia include therapeutic phlebotomy and intravenous fluids.

INTERFERING FACTORS:

- Drugs and substances that may cause a decrease in Hct include those that induce hemolysis due to drug sensitivity or enzyme defi-

ciency, such as acetaminophen, aminopyrine, aminosalicic acid, amphetamine, anticonvulsants, antimalarials, antipyretics, antipyrine, arsenicals, benzene, busulfan, carbenicillin, cephalothin, chemotherapy drugs, chlorate, chloroquine, chlorothiazide, chlorpromazine, colchicine, corticosteroids, dapsone, dimercaprol, diphenhydramine, dipyrone, glucosulfone, glycerin, gold, hydroflumethiazide, indomethacin, mephenytoin, methyldopa, nalidixic acid, neomycin, niridazole, nitrobenzene, nitrofurantoin, novobiocin, penicillin, phenacetamide, phenazopyridine, phenothiazines, and pipobroman (intended effect for polycythemia); and those that result in anemia, such as miconazole, penicillamine, phenylhydrazine, primaquine, probenecid, pyrazolones, pyrimethamine, quinines, streptomycin, sulfamethizole, sulfamethoxyypyridazine, sulfisoxazole, suramin, thioridazine, tolbutamide, trimethadione, and tripeleminamine.

- Some drugs may also affect Hct values by increasing or decreasing the RBC count (see monograph titled "Complete Blood Count, RBC Count").
- The results of RBC counts may vary depending on the patient's position: Hct can decrease when the patient is recumbent as a result of hemodilution and can increase when the patient rises as a result of hemoconcentration.
- Leaving the tourniquet in place for longer than 60 sec can falsely increase Hct levels by 2% to 5%.
- Traumatic venipuncture and hemolysis may result in falsely decreased Hct values.
- Failure to fill the tube sufficiently (i.e., tube less than three-quarters full) may yield inadequate sample volume for automated analyzers

and may be a reason for specimen rejection.

- Clotted or hemolyzed specimens must be rejected for analysis.
- Care should be taken in evaluating the Hct during the first few hours after transfusion or acute blood loss because the value may appear to be normal and may not be a reliable indicator of anemia.
- Abnormalities in the RBC size (macrocytes, microcytes) or shape (spherocytes, sickle cells) may alter Hct values, as in diseases and conditions including sickle cell anemia, hereditary spherocytosis, and iron deficiency.
- Elevated blood glucose or serum sodium levels may produce elevated Hct levels because of swelling of the erythrocytes.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate anemia, polycythemia, and hydration status and to monitor therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, gastrointestinal, hematopoietic, hepatobiliary, immune, musculoskeletal, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to

10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a 5-mL lavender-top (EDTA) tube. An EDTA Microtainer sample may be obtained from infants, children, and adults for whom venipuncture may not be feasible. The specimen should be mixed gently by inverting the tube 10 times. The specimen should be analyzed within 6 hr when stored at room temperature or within 24 hr if stored at refrigerated temperature. If it is anticipated the specimen will not be analyzed within 4 to 6 hr, two blood smears should be made immediately after the venipuncture and submitted with the blood sample. Smears made from specimens older than 6 hr will contain an unacceptable number of misleading artifactual abnormalities of the RBCs, such as echinocytes and spherocytes, as well as necrobiotic white blood cells.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.

- ▶ **Nutritional considerations:** Nutritional therapy may be indicated for patients with decreased Hct. Iron deficiency is the most common nutrient deficiency in the United States. Patients at risk (e.g., children, pregnant women and women of childbearing age, low-income populations) should be instructed to include foods that are high in iron in their diet, such as meats (especially liver), eggs, grains, green leafy vegetables, and multivitamins with iron. Iron absorption is affected by numerous factors (see monograph titled "Iron").
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be

performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, complete blood count, complete blood count, hemoglobin, complete blood count, RBC indices, complete blood count, RBC morphology, erythropoietin, ferritin, iron/TIBC, and reticulocyte count.
- ▶ Refer to the Cardiovascular, Gastrointestinal, Hematopoietic, Hepatobiliary, Immune, Musculoskeletal, and Respiratory System tables at the back of the book for related tests by body system.

Complete Blood Count, Hemoglobin

SYNONYM/ACRONYM: Hgb.

SPECIMEN: Whole blood from one full lavender-top (EDTA) tube, Microtainer, or capillary. Whole blood from a green-top (lithium or sodium heparin) tube may also be submitted.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 10)
Cord blood	13.5–20.5 g/dL	135–205 mmol/L
2 wk	13.4–19.8 g/dL	134–198 mmol/L
1 mo	10.7–17.1 g/dL	107–171 mmol/L
6 mo	11.1–14.4 g/dL	111–144 mmol/L
1 yr	11.3–14.1 g/dL	113–141 mmol/L
9–14 yr	12.0–14.4 g/dL	120–144 mmol/L
Adult (15–64 yr)		
Male	13.2–17.3 g/dL	132–173 mmol/L
Female	11.7–15.5 g/dL	117–155 mmol/L
Older adult (65–74 yr)		
Male	12.6–17.4 g/dL	126–174 mmol/L
Female	11.7–16.1 g/dL	117–161 mmol/L

DESCRIPTION: Hemoglobin (Hgb) is the main intracellular protein of erythrocytes. It carries oxygen (O_2) to and removes carbon dioxide (CO_2) from red blood cells (RBCs). It also serves as a buffer to maintain acid-base balance in the extracellular fluid. Each Hgb molecule consists of heme and globulin. Copper is a cofactor necessary for the enzymatic incorporation of iron molecules into heme. Heme contains iron and porphyrin molecules that have a high affinity for O_2 . The affinity of Hgb molecules for O_2 is influenced by 2,3-diphosphoglycerate (2,3-DPG), a substance produced by anaerobic glycolysis to generate energy for the RBCs. When Hgb binds with 2,3-DPG, O_2 affinity decreases. The ability of Hgb to bind and release O_2 can be graphically represented by an oxyhemoglobin dissociation curve. The term *shift to the left* is used to describe an increase in the affinity of Hgb for O_2 . Conditions that can cause this leftward shift include decreased body temperature, decreased 2,3-DPG, decreased CO_2 concentration, and increased pH. Conversely, a *shift to the right* represents a decrease in the affinity of Hgb for O_2 . Conditions that can cause a rightward shift include increased body temperature, increased 2,3-DPG levels, increased CO_2 concentration, and decreased pH.

Hgb levels are a direct reflection of the O_2 -combining capacity of the blood. It is the combination of heme and O_2 that gives blood its characteristic red color. RBC counts parallel the O_2 -combining capacity of Hgb, but because some RBCs contain more Hgb than others, the relationship is not directly proportional. As CO_2 diffuses into RBCs, an

enzyme called carbonic anhydrase converts the CO_2 into bicarbonate and hydrogen ions. Hgb that is not bound to O_2 combines with the free hydrogen ions, increasing pH. As this binding is occurring, bicarbonate is leaving the RBC in exchange for chloride ions. (For additional information about the relationship between the respiratory and renal components of this buffer system, see monograph titled "Blood Gases.")

Hgb is included in the complete blood count (CBC) and generally performed with a hematocrit (Hct). These levels parallel each other and are frequently used to evaluate anemia. *Polycythemia* is a term used in conjunction with conditions resulting from an abnormal increase in Hgb, Hct, and RBC count. *Anemia* is a term associated with conditions resulting from an abnormal decrease in Hgb, Hct, and RBC count. Results of the Hgb, Hct, and RBC count should be evaluated simultaneously because the same underlying conditions affect this triad of tests similarly. The RBC count multiplied by 3 should approximate the Hgb concentration. The Hct should be within three times the Hgb if the RBC population is normal in size and shape. The Hct plus 6 should approximate the first two figures of the RBC count within 3 (e.g., Hct is 40%; therefore $40 + 6 = 46$, and the RBC count should be 4.6 or in the range of 4.3 to 4.9). There are some cultural variations in Hgb and Hct (H&H) values. After the first decade of life, the mean Hgb in African Americans is 0.5 to 1.0 g lower than in whites. Mexican Americans and Asian Americans have higher Hgb and H&H values than whites.

INDICATIONS:

- Detect hematologic disorder, neoplasm, or immunologic abnormality
- Determine the presence of hereditary hematologic abnormality
- Evaluate known or suspected anemia and related treatment, in combination with Hct
- Monitor blood loss and response to blood replacement, in combination with Hct
- Monitor the effects of physical or emotional stress on the patient
- Monitor fluid imbalances or their treatment
- Monitor hematologic status during pregnancy, in combination with Hct
- Monitor the progression of non-hematologic disorders, such as chronic obstructive pulmonary disease (COPD), malabsorption syndromes, cancer, and renal disease
- Monitor response to drugs or chemotherapy, and evaluate undesired reactions to drugs that may cause blood dyscrasias
- Provide screening as part of a CBC in a general physical examination, especially upon admission to a health care facility or before surgery

RESULT:**Increased in:**

- Burns (*Related to dehydration; total blood volume is decreased but RBC count remains the same*)
- Congestive heart failure (*When the underlying cause is anemia, the body will respond by increasing production of RBCs; with a responding increase in Hct*)
- COPD (*Related to chronic hypoxia that stimulates production of RBCs and a corresponding increase in Hgb*)
- Dehydration (*Total blood volume is decreased but RBC count remains the same*)
- Erythrocytosis (*Total blood volume remains the same but RBC count is increased*)
- Hemoconcentration (*Same effect as seen in dehydration*)
- High altitudes (*Related to hypoxia that stimulates production of RBCs and therefore increases Hgb*)
- Polycythemia vera (*Abnormal bone marrow response resulting in overproduction of RBCs*)

Decreased in:

- Anemias (*Overall decrease in RBCs and corresponding decrease in Hgb*)
- Carcinoma (*Anemia is often associated with chronic disease*)
- Fluid retention (*Dilutional effect of increased blood volume while RBC count remains stable*)
- Hemoglobinopathies (*Reduced RBC survival with corresponding decrease in Hgb*)
- Hemolytic disorders (*Reduced RBC survival with corresponding decrease in Hgb*)
- Hemorrhage (acute and chronic) (*Overall decrease in RBCs and corresponding decrease in Hgb*)
- Hodgkin's disease (*Bone marrow failure that results in decreased RBC production*)
- Incompatible blood transfusion (*Reduced RBC survival with corresponding decrease in Hgb*)
- Intravenous overload (*Dilutional effect*)
- Leukemia (*Bone marrow failure that results in decreased RBC production*)
- Lymphomas (*Bone marrow failure that results in decreased RBC production*)
- Nutritional deficit (*Anemia related to dietary deficiency in iron, vitamins, folate needed to produce sufficient RBCs; decreased RBC count with corresponding decrease in Hgb*)
- Pregnancy (*Related to anemia*)
- Splenomegaly (*Total blood volume remains the same but spleen retains RBCs and Hgb reflects decreased RBC count*)

CRITICAL VALUES:

Less than 6.0 g/dL

Greater than 18.0 g/dL

Note and immediately report to the health care practitioner any critically increased or decreased values and related symptoms.

- Low Hgb leads to anemia. Anemia can be caused by blood loss, decreased blood cell production, increased blood cell destruction, and hemodilution. Causes of blood loss include menstrual excess or frequency, gastrointestinal bleeding, inflammatory bowel disease, and hematuria. Decreased blood cell production can be caused by folic acid deficiency, vitamin B₁₂ deficiency, iron deficiency, and chronic disease. Increased blood cell destruction can be caused by a hemolytic reaction, chemical reaction, medication reaction, and sickle cell disease. Hemodilution can be caused by congestive heart failure, renal failure, polydipsia, and overhydration. Symptoms of anemia (due to these causes) include anxiety, dyspnea, edema, hypertension, hypotension, hypoxia, jugular venous distention, fatigue, pallor, rales, restlessness, and weakness. Treatment of anemia depends on the cause.
- High Hgb leads to polycythemia. Polycythemia can be caused by dehydration, decreased oxygen levels in the body, and an overproduction of RBCs by the bone marrow. Dehydration from diuretic use, vomiting, diarrhea, excessive sweating, severe burns, or decreased fluid intake decreases the plasma component of whole blood, thereby increasing the ratio of RBCs to plasma and leads to a higher than normal Hgb. Causes of decreased oxygen include smoking, exposure to carbon monoxide, high altitude, and chronic lung disease, which leads to a mild hemoconcentration of blood

in the body to carry more oxygen to the body's tissues. An overproduction of RBCs by the bone marrow leads to polycythemia vera, which is a rare chronic myeloproliferative disorder that leads to a severe hemoconcentration of blood. Severe hemoconcentration can lead to thrombosis (spontaneous blood clotting). Symptoms of hemoconcentration include decreased pulse pressure and volume, loss of skin turgor, dry mucous membranes, headaches, hepatomegaly, low central venous pressure, orthostatic hypotension, pruritis (especially after a hot bath), splenomegaly, tachycardia, thirst, tinnitus, vertigo, and weakness. Treatment of polycythemia depends on the cause. Possible interventions for hemoconcentration due to dehydration include intravenous fluids and discontinuance of diuretics if they are believed to be contributing to critically elevated Hgb. Polycythemia due to decreased oxygen states can be treated by removal of the offending substance, such as smoke or carbon monoxide. Treatment includes oxygen therapy in cases of smoke inhalation, carbon monoxide poisoning, and desaturating chronic lung disease. Symptoms of polycythemic overload crisis include signs of thrombosis, pain and redness in extremities, facial flushing, and irritability. Possible interventions for hemoconcentration due to polycythemia include therapeutic phlebotomy and intravenous fluids.

INTERFERING FACTORS:

- Drugs and substances that may cause a decrease in Hgb levels include those that induce hemolysis due to drug sensitivity or enzyme deficiency, such as acetaminophen, aminopyrine, aminosalicic acid, amphetamine, anticonvulsants,

antimalarials, antipyretics, antipyrine, arsenicals, benzene, busulfan, carbenicillin, cephalothin, chemotherapy drugs, chlorate, chloroquine, chlorothiazide, chlorpromazine, colchicine, corticosteroids, dapsone, dimercaprol, diphenhydramine, dipyrone, glucosulfone, glycerin, gold, hydroflumethiazide, indomethacin, mephenytoin, methyl dopa, nalidixic acid, neomycin, niridazole, nitrobenzene, nitrofurantoin, novobiocin, penicillin, phenacetamide, phenazopyridine, and phenothiazines; and those that result in anemia, such as miconazole, penicillamine, phenylhydrazine, primaquine, probenecid, pyrazolones, pyrimethamine, quinines, streptomycin, sulfamethizole, sulfamethoxy pyridazine, sulfisoxazole, suramin, thioridazine, tolbutamide, trimethadione, and tripeleminamine.

- Some drugs may also affect Hgb values by increasing or decreasing the RBC count (see monograph titled “Complete Blood Count, RBC Count”).
- The results of RBC counts may vary depending on the patient's position: Hgb can decrease when the patient is recumbent as a result of hemodilution and can increase when the patient rises as a result of hemoconcentration.
- Use of the neutraceutical liver extract is strongly contraindicated in iron-storage disorders, such as hemochromatosis, because it is rich in heme (the iron-containing pigment in Hgb).
- A severe copper deficiency may result in decreased Hgb levels.
- Cold agglutinins may falsely increase the mean corpuscular Hgb concentration (MCHC) and decrease the RBC count, affecting Hgb values. This can be corrected by warming the blood or replacing the plasma with warmed saline and repeating the analysis.

- Leaving the tourniquet in place for longer than 60 sec can falsely increase Hgb levels by 2% to 5%.
- Failure to fill the tube sufficiently (i.e., tube less than three-quarters full) may yield inadequate sample volume for automated analyzers and may be a reason for specimen rejection.
- Clotted or hemolyzed specimens must be rejected for analysis.
- Care should be taken in evaluating the Hgb during the first few hours after transfusion or acute blood loss because the value may appear to be normal.
- Abnormalities in the RBC size (macrocytes, microcytes) or shape (spherocytes, sickle cells) may alter Hgb values, as in diseases and conditions including sickle cell anemia, hereditary spherocytosis, and iron deficiency.
- Lipemia will falsely increase the Hgb measurement, also affecting the mean corpuscular volume (MCV) and MCHC. This can be corrected by replacing the plasma with saline, repeating the measurement, and manually correcting the Hgb, MCH, and MCHC using specific mathematical formulas.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate anemia, polycythemia, and hydration status and to monitor therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, gastrointestinal, hematopoietic, hepatobiliary, immune, musculoskeletal, and respiratory systems, symptoms, and results of previously performed laboratory

tests and diagnostic and surgical procedures.

- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a 5-mL lavender-top (EDTA) tube. An EDTA Microtainer sample may be obtained from infants, children, and adults for whom venipuncture may not be feasible. The specimen should be mixed gently by inverting the tube 10 times. The specimen should be analyzed within 6 hr when stored at room temperature or within 24 hr if stored at refrigerated temperature. If it is anticipated the specimen will not be analyzed within 4 to 6 hr, two blood smears should be made immediately after the venipuncture and submitted with the blood sample. Smears made from specimens older than 6 hr will contain an unacceptable number of misleading artifactual abnormalities of the RBCs, such as echinocytes and spherocytes, as well as necrobiotic white blood cells.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop

bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Nutritional therapy may be indicated for patients with decreased Hgb. Iron deficiency is the most common nutrient deficiency in the United States. Patients at risk (e.g., children, pregnant women and women of childbearing age, low-income populations) should be instructed to include foods that are high in iron in their diet, such as meats (especially liver), eggs, grains, green leafy vegetables, and multivitamins with iron. Iron absorption is affected by numerous factors (see monograph titled "Iron").
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, biopsy lymph node, biopsy kidney, blood groups and antibodies, complete blood count, Coomb's antiglobulin, CT thoracic, erythropoietin, fecal analysis (occult blood), ferritin, gallium scan, hapto-globin, complete blood count hematocrit, hemoglobin electrophoresis, iron/TIBC, lymphangiogram, Meckel's diverticulum scan, reticulocyte count, and sickle cell screen.
- ▶ Refer to the Cardiovascular, Gastrointestinal, Hematopoietic, Hepatobiliary, Immune, Musculoskeletal, and Respiratory System tables at the back of the book for related tests by body system.

Complete Blood Count, Platelet Count

SYNONYM/ACRONYM: Thrombocytes.

SPECIMEN: Whole blood from one full lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Automated, computerized multichannel analyzers that sort and size cells on the basis of either changes in electrical impedance or light pulses as the cells pass in front of a laser)

Age	Platelet Count*	SI Units (Conventional Units $\times 10^6$)	MPV (fL)
1–5 yr	217–497 $\times 10^3/\text{mm}^3$ or 217,000–497,000/ mm^3	217–497 $\times 10^9/\text{L}$	7.2–10.0
Adult	150–450 $\times 10^3/\text{mm}^3$ or 150,000–450,000/ mm^3	150–450 $\times 10^9/\text{L}$	7.0–10.2

Note: Platelet counts decrease with age.

*Conventional units.

MPV = mean platelet volume.

DESCRIPTION: *Platelets* are non-nucleated, cytoplasmic, round or oval disks formed by budding off of large, multinucleated cells (megakaryocytes). Platelets have an essential function in coagulation, hemostasis, and blood thrombus formation. *Thrombocytosis* is an increase in platelet count. In reactive thrombocytosis, the increase is transient and short-lived, and it usually does not pose a health risk. One exception may be reactive thrombocytosis occurring after coronary bypass surgery. This circumstance has been identified as an important risk factor for postoperative infarction and thrombosis. The term *thrombocythemia* is used to describe platelet increases associated with chronic myeloproliferative disorders; *thrombocytopenia* is used to describe platelet counts of less than $140 \times 10^3/\text{microL}$.

Decreased platelet counts occur whenever the body's need for platelets exceeds the rate of platelet production; this circumstance will arise if production rate decreases or platelet loss increases. The severity of bleeding is related to platelet count as well as platelet function. Platelet counts can be within normal limits, but the patient may exhibit signs of internal bleeding; this circumstance usually indicates an anomaly in platelet function. Abnormal scatterplot findings by automated cell counters may indicate the need to review a smear of peripheral blood for platelet estimate. Abnormally large or giant platelets may result in underestimation of automated counts by 30% to 50%. A large discrepancy between the automated count and the estimate requires that a manual count be performed.

The significance of platelet sizing is becoming more widely known, as modern cell counters are capable of reporting platelet indexes that are analogous to red blood cell (RBC) indices. Platelet size, reflected by mean platelet volume (MPV), and cellular age are inversely related; that is, younger platelets tend to be larger. An increase in MPV indicates an increase in platelet turnover. Therefore, in a normal patient the platelet count and MPV have an inverse relationship. Abnormal platelet size may also indicate the presence of a disorder. MPV and platelet distribution width (PDW) are both increased in idiopathic thrombocytopenic purpura. MPV is also increased in May-Hegglin anomaly, Bernard-Soulier syndrome, myeloproliferative disorders, hyperthyroidism, and pre-eclampsia. MPV is decreased in Wiskott-Aldrich syndrome, septic thrombocytopenia, and hypersplenism.

Medications like clopidogrel (Plavix®) and aspirin have antiplatelet effects and are prescribed to prevent heart attack, stroke, and blockage of coronary stents. Studies have confirmed that up to 30% of patients receiving these medications may be nonresponsive. Tests to assess platelet function can provide information that confirms platelet response. Platelet response testing helps ensure alternative or additional platelet therapy is instituted, if necessary. The test results can also be used preoperatively to determine whether antiplatelet medications have been sufficiently cleared from the patient's circulation such that surgery can safely be performed without risk of excessive bleeding.

INDICATIONS:

- Confirm an elevated platelet count (thrombocytosis), which can cause increased clotting
- Confirm a low platelet count (thrombocytopenia), which can be associated with bleeding
- Identify the possible cause of abnormal bleeding, such as epistaxis, hematoma, gingival bleeding, hematuria, and menorrhagia
- Provide screening as part of a complete blood count (CBC) in a general physical examination, especially upon admission to a health care facility or before surgery

RESULT:

Increased in:

Conditions that involve inflammation activate and increase the number of circulating platelets:

- Acute infections
- After exercise (transient)
- Anemias (posthemorrhagic, hemolytic, iron-deficiency) (***Bone marrow response to anemia; platelet formation is unaffected by iron deficiency***)
- Chronic heart disease
- Cirrhosis
- Essential thrombocythemia
- Leukemias (chronic)
- Malignancies (carcinoma, Hodgkin's, lymphomas)
- Pancreatitis (chronic)
- Polycythemia vera (***Hyperplastic bone marrow response in all cell lines***)
- Rebound recovery from thrombocytopenia (***Initial response***)
- Rheumatic fever (acute)
- Rheumatoid arthritis
- Splenectomy (2 mo postprocedure) (***Normal function of the spleen is to cull aging cells from the blood; without the spleen the count increases***)
- Surgery (2 wk postprocedure)

- Trauma
- Tuberculosis
- Ulcerative colitis

Decreased in:

Decreased in (as a result of Megakaryocytic Hypoproliferation):

- Alcohol toxicity
- Aplastic anemia
- Congenital states (Fanconi's syndrome, May-Hegglin anomaly, Bernard-Soulier syndrome, Wiskott-Aldrich syndrome, Gaucher's disease, Chédiak-Higashi syndrome)
- Drug toxicity
- Prolonged hypoxia

Decreased in (as a result of ineffective thrombopoiesis):

- Ethanol abuse without malnutrition
- Iron-deficiency anemia
- Megaloblastic anemia (B_{12} /folate deficiency)
- Paroxysmal nocturnal hemoglobinuria
- Thrombopoietin deficiency
- Viral infection

Decreased in (as a result of bone marrow replacement):

- Lymphoma
- Granulomatous infections
- Metastatic carcinoma
- Myelofibrosis

Increased in:

Increased destruction in (as a result of increased loss/consumption):

- Contact with foreign surfaces (dialysis membranes, artificial organs, grafts, prosthetic devices)
- Disseminated intravascular coagulation
- Extensive transfusion
- Severe hemorrhage
- Thrombotic thrombocytopenic purpura
- Uremia

Increased destruction in (as a result of immune reaction):

- Antibody/human leukocyte antigen reactions
- Hemolytic disease of the newborn (*target is platelets instead of RBCs*)
- Idiopathic thrombocytopenic purpura
- Refractory reaction to platelet transfusion

Increased destruction in (as a result of immune reaction secondary to infection):

- Bacterial infections
- Burns
- Congenital infections (cytomegalovirus, herpes, syphilis, toxoplasmosis)
- Histoplasmosis
- Malaria
- Rocky Mountain spotted fever

Increased destruction in (as a result of other causes):

- Radiation
- Splenomegaly caused by liver disease

CRITICAL VALUES: 

- Less than $50,000 \times 10^3/\text{microL}$ (or $50 \times 10^3/\text{mm}^3$ or $50,000/\text{mm}^3$)
- Greater than $1,000 \times 10^3/\text{microL}$ (or $1,000,000/\text{mm}^3$)

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms. Possible interventions for decreased platelet count may include transfusion of platelets.

INTERFERING FACTORS:

- Drugs that may decrease platelet counts include acetohexamide, acetophenazine, amphotericin B, antazoline, anticonvulsants, antimony compounds, apronalide, arsenicals, azathioprine, barbiturates, benzene, busulfan, butaperazine, chlordane,

chlorophenothane, chlortetracycline, dactinomycin, dextromethorphan, diethylstilbestrol, ethinamate, ethoxzolamide, floxuridine, hexachlorobenzene, hydantoin derivatives, hydroflumethiazide, hydroxychloroquine, iproniazid, mechlorethamine, mefenamic acid, mepazine, miconazole, mitomycin, nitrofurantoin, novobiocin, nystatin, phenolphthalein, phenothiazine, pipamazine, plicamycin, procarbazine, pyrazolones, streptomycin, sulfonamides, tetracycline, thiabendazole, thiouracil, tolazamide, tolazoline, tolbutamide, trifluoperazine, and urethane.

- Drugs that may increase platelet counts include glucocorticoids.
- X-ray therapy may also decrease platelet counts.
- The results of blood counts may vary depending on the patient's position. Platelet counts can decrease when the patient is recumbent, as a result of hemodilution, and can increase when the patient rises, as a result of hemoconcentration.
- Platelet counts normally increase under a variety of stressors, such as high altitudes or strenuous exercise.
- Platelet counts are normally decreased before menstruation and during pregnancy.
- Leaving the tourniquet in place for longer than 60 sec can affect the results.
- Traumatic venipunctures may lead to erroneous results as a result of activation of the coagulation sequence.
- Failure to fill the tube sufficiently (i.e., tube less than three-quarters full) may yield inadequate sample volume for automated analyzers and may be a reason for specimen rejection.

- Hemolysis or clotted specimens are reasons for rejection.
- CBC should be carefully evaluated after transfusion or acute blood loss because the value may appear to be normal.
- A white blood cell count greater than $100 \times 10^3/\text{mm}^3$, severe RBC fragmentation, and extraneous particles in the fluid used to dilute the sample can alter test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate, diagnose, and monitor bleeding disorders.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and immune systems, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. The specimen should be mixed gently by inverting the tube 10 times. The specimen should be analyzed within 6 hr when stored at room temperature or within 24 hr if stored at refrigerated temperature. If it is anticipated the specimen will not be analyzed within 4 to 6 hr, two blood smears should be made immediately after the venipuncture and submitted with the blood sample.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to report bleeding from any areas of the skin or mucous membranes.
- ◆ Inform the patient with a decreased platelet count of the importance of taking precautions against bruising

and bleeding, including the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of acetylsalicylic acid and similar products, and avoidance of intramuscular injections.

- ◆ Inform the patient of the importance of periodic laboratory testing if he or she is taking an anticoagulant.
- ◆ *Nutritional considerations:* Instruct patients to consume a variety of foods within the basic food groups, maintain a healthy weight, be physically active, limit salt intake, limit alcohol intake, and avoid the use of tobacco.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include antiarrhythmic drugs (quinidine), biopsy bone marrow, bleeding time, blood groups and antibodies, clot retraction, coagulation factors, complete blood count, CT angiography, CT brain, FDP, fibrinogen, PTT, platelet antibodies, PT/INR, complete blood count RBC morphology and inclusions, US pelvis, and complete blood count WBC count and differential.
- ◆ Refer to the Hematopoietic and Immune System tables at the back of the book for related tests by body system.

Complete Blood Count, RBC Count

SYNONYM/ACRONYM: RBC.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Automated, computerized, multichannel analyzers that sort and size cells on the basis of changes in either electrical impedance or light pulses as the cells pass in front of a laser)

Age	Conventional Units	SI Units (Conventional Units × 1)
Cord Blood	4.14–4.69 × 10 ⁶ cells/mm ³	4.14–4.69 × 10 ¹² cells/L
1 d	5.33–5.47 × 10 ⁶ cells/mm ³	5.33–5.47 × 10 ¹² cells/L
2 wk	4.32–4.98 × 10 ⁶ cells/mm ³	4.32–4.98 × 10 ¹² cells/L
1 mo	3.75–4.95 × 10 ⁶ cells/mm ³	3.75–4.95 × 10 ¹² cells/L
6 mo	3.71–4.25 × 10 ⁶ cells/mm ³	3.71–4.25 × 10 ¹² cells/L
1 yr	4.40–4.48 × 10 ⁶ cells/mm ³	4.40–4.48 × 10 ¹² cells/L
10 yr	4.75–4.85 × 10 ⁶ cells/mm ³	4.75–4.85 × 10 ¹² cells/L
Adult male	4.71–5.14 × 10 ⁶ cells/mm ³	4.71–5.14 × 10 ¹² cells/L
Adult female	4.20–4.87 × 10 ⁶ cells/mm ³	4.20–4.87 × 10 ¹² cells/L

DESCRIPTION: A component of the complete blood count (CBC), the red blood cell (RBC) count determines the number of RBCs per cubic millimeters (expressed as the number of RBCs per liter of blood according to the international system of units [SI]). Because RBCs contain hemoglobin (Hgb), which is responsible for the transport and exchange of oxygen, the number of circulating RBCs is important. Although the life span of the normal RBC is 120 days, other factors besides cell age and decreased production can cause decreased values; examples are abnormal destruction due to intravascular trauma caused by atherosclerosis or to an enlarged spleen caused by leukemia. The main sites of RBC production in healthy adults include the bone marrow of the vertebrae, pelvis, ribs, sternum, skull, and

proximal ends of the femur and humerus. The main sites of RBC destruction are the spleen and liver. Erythropoietin, a hormone produced by the kidneys, regulates RBC production. Normal RBC development and function are also dependent on adequate levels of vitamin B₁₂, folic acid, and iron. A deficiency in vitamin E (α-tocopherol), which is needed to protect the RBC membrane from oxidizers, can result in increased cellular destruction. *Polycythemia* is a term used in conjunction with conditions resulting from an abnormal increase in Hgb, hematocrit (Hct), and RBC count. *Anemia* is a term associated with conditions resulting from an abnormal decrease in Hgb, Hct, and RBC count. Results of the Hgb, Hct, and RBC count should be evaluated simultaneously because the same underlying

conditions affect this triad of tests similarly. The RBC count multiplied by 3 should approximate the Hgb concentration. The Hct should be within three times the Hgb if the RBC population is normal in size and shape. The Hct plus 6 should approximate the first two figures of the RBC count within 3 (e.g., Hct is 40%; therefore $40 + 6 = 46$, and the RBC count should be 4.6 or in the range 4.3 to 4.9). (See monographs titled “Complete Blood Count, Hematocrit,” “Complete Blood Count, Hemoglobin,” and “Complete Blood Count, RBC Indices.”)

INDICATIONS:

- Detect a hematological disorder involving RBC destruction (e.g., hemolytic anemia)
- Determine the presence of hereditary hematological abnormality
- Monitor the effects of acute or chronic blood loss
- Monitor the effects of physical or emotional stress on the patient
- Monitor patients with disorders associated with elevated erythrocyte counts (e.g., polycythemia vera, chronic obstructive pulmonary disease [COPD])
- Monitor the progression of nonhematological disorders associated with elevated erythrocyte counts, such as COPD, liver disease, hypothyroidism, adrenal dysfunction, bone marrow failure, malabsorption syndromes, cancer, and renal disease
- Monitor the response to drugs or chemotherapy and evaluate undesired reactions to drugs that may cause blood dyscrasias
- Provide screening as part of a CBC in a general physical examination, especially upon admission to a health care facility or before surgery

RESULT:

Increased in:

- Anxiety or stress (**Related to physiological response**)
- Bone marrow failure (**Initial response is stimulation of RBC production**)
- COPD with hypoxia and secondary polycythemia (**Related to chronic hypoxia that stimulates production of RBCs and a corresponding increase in RBCs**)
- Dehydration with hemoconcentration (**Total blood volume decreases but RBC count remains the same**)
- Erythremic erythrocytosis (**Total blood volume remains the same but RBC count is increased**)
- High altitude (**Related to hypoxia that stimulates production of RBCs**)
- Polycythemia vera (**Abnormal bone marrow response resulting in overproduction of RBCs**)

Decreased in:

- Chemotherapy (**Reduced RBC survival**)
- Chronic inflammatory diseases (**Anemia is often associated with chronic disease**)
- Hemoglobinopathy (**Reduced RBC survival**)
- Hemolytic anemia (**Reduced RBC survival**)
- Hemorrhage (**Overall decrease in RBC count**)
- Hodgkin's disease (**Bone marrow failure that results in decreased RBC production**)
- Leukemia (**Bone marrow failure that results in decreased RBC production**)
- Multiple myeloma (**Bone marrow failure that results in decreased RBC production**)
- Nutritional deficit (**Deficiency of iron or vitamins required for RBC production and/or maturation**)
- Overhydration (**Blood volume increases but RBC count remains the same**)

- Pregnancy (*Related to anemia; normal dilutional effect*)
- Renal disease (*Related to decreased production of erythropoietin*)
- Subacute endocarditis

CRITICAL VALUES:

The presence of abnormal cells, other morphological characteristics, or cellular inclusions may signify a potentially life-threatening or serious health condition and should be investigated. Examples are the presence of sickle cells, moderate numbers of spherocytes, marked schistocytosis, oval macrocytes, basophilic stippling, nucleated RBCs (if the patient is not an infant), or malarial organisms.

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

- Low RBC count leads to anemia. Anemia can be caused by blood loss, decreased blood cell production, increased blood cell destruction, or hemodilution. Causes of blood loss include menstrual excess or frequency, gastrointestinal bleeding, inflammatory bowel disease, or hematuria. Decreased blood cell production can be caused by folic acid deficiency, vitamin B₁₂ deficiency, iron deficiency, or chronic disease. Increased blood cell destruction can be caused by a hemolytic reaction, chemical reaction, medication reaction, or sickle cell disease. Hemodilution can be caused by congestive heart failure, renal failure, polydipsia, or overhydration. Symptoms of anemia (due to these causes) include anxiety, dyspnea, edema, hypertension, hypotension, hypoxia, jugular venous distention, fatigue, pallor, rales, restlessness, and weakness. Treatment of anemia depends on the cause.
- High RBC count leads to polycythemia. Polycythemia can be

caused by dehydration, decreased oxygen levels in the body, and an overproduction of RBCs by the bone marrow. Dehydration by diuretic use, vomiting, diarrhea, excessive sweating, severe burns, or decreased fluid intake decreases the plasma component of whole blood, thereby increasing the ratio of RBCs to plasma, and leads to a higher than normal Hct. Causes of decreased oxygen include smoking, exposure to carbon monoxide, high altitude, and chronic lung disease, which leads to a mild hemoconcentration of blood in the body to carry more oxygen to the body's tissues. An overproduction of RBCs by the bone marrow leads to polycythemia vera, which is a rare chronic myeloproliferative disorder that leads to a severe hemoconcentration of blood. Severe hemoconcentration can lead to thrombosis (spontaneous blood clotting). Symptoms of hemoconcentration include decreased pulse pressure and volume, loss of skin turgor, dry mucous membranes, headaches, hepatomegaly, low central venous pressure, orthostatic hypotension, pruritis (especially after a hot bath), splenomegaly, tachycardia, thirst, tinnitus, vertigo, and weakness. Treatment of polycythemia depends on the cause. Possible interventions for hemoconcentration due to dehydration include intravenous fluids and discontinuance of diuretics if they are believed to be contributing to critically elevated Hct. Polycythemia due to decreased oxygen states can be treated by removal of the offending substance, such as smoke or carbon monoxide. Treatment includes oxygen therapy in cases of smoke inhalation, carbon monoxide poisoning, and desaturating chronic lung disease. Symptoms of polycythemic overload crisis include signs of thrombosis, pain and redness in

extremities, facial flushing, and irritability. Possible interventions for hemoconcentration due to polycythemia include therapeutic phlebotomy and intravenous fluids.

INTERFERING FACTORS:

- Drugs and substances that may decrease RBC count by causing hemolysis resulting from drug sensitivity or enzyme deficiency include acetaminophen, aminopyrine, aminosalicic acid, amphetamine, anticonvulsants, antipyrine, arsenicals, benzene, busulfan, carbenicillin, cephalothin, chemotherapy drugs, chlorate, chloroquine, chlorothiazide, chlorpromazine, colchicine, diphenhydramine, dipyrone, glucosulfone, gold, hydroflumethiazide, indomethacin, mephenytoin, nalidixic acid, neomycin, nitrofurantoin, penicillin, phenacetamide, phenazopyridine, and phenothiazine.
- Drugs that may decrease RBC count by causing anemia include miconazole, penicillamine, phenylhydrazine, primaquine, probenecid, pyrazolones, pyrimethamine, quinines, streptomycin, sulfamethizole, sulfamethoxyypyridine, sulfisoxazole, suramin, thioridazine, tolbutamide, trimethadione, and tripeleennamine.
- Drugs that may decrease RBC count by causing bone marrow suppression include amphotericin B, floxuridine, and phenylbutazone.
- Drugs and vitamins that may increase the RBC count include glucocorticosteroids, pilocarpine, and vitamin B₁₂.
- Use of the neutraceutical liver extract is strongly contraindicated in patients with iron-storage disorders such as hemochromatosis because it is rich in heme (the iron-containing pigment in Hgb).
- Hemodilution (e.g., excessive administration of intravenous fluids, normal pregnancy) in the presence of a normal number of

RBCs may lead to false decreases in RBC count.

- Cold agglutinins may falsely increase the mean corpuscular volume (MCV) and decrease the RBC count. This can be corrected by warming the blood or diluting the sample with warmed saline and repeating the analysis.
- Excessive exercise, anxiety, pain, and dehydration may cause false elevations in RBC count.
- A grossly elevated white blood cell (WBC) count (greater than $500 \times 10^3/\text{mm}^3$) will cause a falsely elevated RBC count. This can be corrected by diluting the sample with saline to obtain an accurate WBC count and then correcting the RBC mathematically.
- Care should be taken in evaluating the CBC after transfusion.
- RBC counts can vary depending on the patient's position, decreasing when the patient is recumbent as a result of hemodilution and increasing when the patient rises as a result of hemoconcentration.
- Venous stasis can falsely elevate RBC counts; therefore, the tourniquet should not be left on the arm for longer than 60 sec.
- Failure to fill the tube sufficiently (i.e., tube less than three-quarters full) may yield inadequate sample volume for automated analyzers and may be a reason for specimen rejection.
- Hemolyzed or clotted specimens must be rejected for analysis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate anemia and disorders affecting the number of circulating RBCs.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, gastrointestinal, genitourinary, hematopoietic, hepatobiliary, immune, musculoskeletal, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. An EDTA Microtainer sample may be obtained from infants, children, and adults for whom venipuncture may not be feasible. The specimen should be mixed gently by inverting the tube 10 times. The specimen should be analyzed within 6 hr when stored at room temperature or within 24 hr if stored at refrigerated temperature. If it is anticipated the specimen will not be analyzed within 4 to 6 hr, two blood smears

should be made immediately after the venipuncture and submitted with the blood sample. Smears made from specimens older than 6 hr will contain an unacceptable number of misleading artifactual abnormalities of the RBCs, such as echinocytes and spherocytes, as well as necrobiotic WBCs.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Nutritional therapy may be indicated for patients with decreased RBC count. Iron deficiency is the most common nutrient deficiency in the United States. Patients at risk (e.g., children, pregnant women and women of childbearing age, low-income populations) should be instructed to include foods that are high in iron in their diet, such as meats (especially liver), eggs, grains, green leafy vegetables, and multivitamins with iron. Iron absorption is affected by numerous factors (see monograph titled "Iron").
- ▶ **Nutritional considerations:** Patients at risk for vitamin B₁₂ or folate deficiency include those with the following conditions: malnourishment (inadequate intake), pregnancy (increased need), infancy, malabsorption syndromes (inadequate absorption/increased metabolic rate), infections, cancer, hyperthyroidism, serious burns, excessive blood loss, and gastrointestinal damage. These patients should be instructed, as appropriate, to ingest food sources rich in vitamin B₁₂, such as meats, milk, cheese, eggs, and fortified soy milk products. Sources of folate are meats (especially liver), kidney beans, beets, vegetables in the cabbage family, oranges, cantaloupe, and green leafy vegetables such as spinach, asparagus, and broccoli.
- ▶ **Nutritional considerations:** A diet deficient in vitamin E puts the patient at risk for increased RBC destruction, which

could lead to anemia. Nutritional therapy may be indicated for these patients. Vitamin E is found in many of the previously mentioned foods, as well as in vegetable oils and wheat germ. Supplemental vitamin E may also be taken, but the danger of toxicity should be explained to the patient. Very large supplemental doses, in excess of 600 mg of vitamin E over a period of 1 yr, may result in excess bleeding. Vitamin E is heat stable but is very negatively affected by light.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change

in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include biopsy bone marrow, biopsy kidney, blood groups and antibodies, complete blood count, complete blood count hematocrit, complete blood count hemoglobin, complete blood count, RBC morphology and inclusions, Coomb's antiglobulin, erythropoietin, fecal analysis, ferritin, folate, gallium scan, haptoglobin, iron/TIBC, lymphangiogram, Meckel's diverticulum scan, reticulocyte count, and vitamin B₁₂.
- ◆ Refer to the Cardiovascular, Gastrointestinal, Genitourinary, Hematopoietic, Hepatobiliary, Immune, Musculoskeletal, and Respiratory System tables at the back of the book for related tests by body system.

Complete Blood Count, RBC Indices

SYNONYM/ACRONYM: Mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), red blood cell distribution width (RDW).

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Automated, computerized, multichannel analyzers that sort and size cells on the basis of changes in either electrical impedance or light pulses as the cells pass in front of a laser)

Age	MCV* (fL)	MCH (pg/cell)	MCHC (g/dL)	RDW
Cord blood	107–119	35–39	32–34	14.9–18.7
1 d	104–116	35–39	32–34	14.9–18.7
2 wk	95–117	29–35	28–32	14.9–18.7
1 mo	93–115	29–35	28–34	14.9–18.7
6 mo	82–100	24–30	28–32	14.9–18.7
1 yr	81–95	25–29	29–31	11.6–14.8
10 yr	75–87	25–31	33–35	11.6–14.8
Adult male	85–95	28–32	33–35	11.6–14.8
Adult female	85–95	28–32	33–35	11.6–14.8

*MCV = mean corpuscular volume; MCH = mean corpuscular hemoglobin; MCHC = mean corpuscular hemoglobin concentration; RDW = red blood cell distribution width.

DESCRIPTION: Red blood cell (RBC) indices provide information about the mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and RBC distribution width (RDW). The hematocrit, RBC count, and total hemoglobin tests are used to determine the RBC indices. MCV is determined by dividing the hematocrit by the total RBC count and is helpful in classifying anemias. MCH is determined by dividing the total hemoglobin concentration by the RBC count. MCHC is determined by dividing total hemoglobin by hematocrit. Hemoglobin content is indicated as normochromic, hypochromic, and hyperchromic. The RDW is a measurement of cell size distribution over the entire RBC population measured. It can indicate anisocytosis, or excessive variations in cell size. Cell size is indicated as normocytic, microcytic, and macrocytic. (See monographs titled “Complete Blood Count, Hemoglobin,” “Complete Blood Count, Hematocrit,” “Complete Blood Count, RBC Count,” and “Complete Blood Count, RBC Morphology and Inclusions.”)

INDICATIONS:

- Assist in the diagnosis of anemia
- Detect a hematological disorder, neoplasm, or immunological abnormality
- Determine the presence of a hereditary hematological abnormality
- Monitor the effects of physical or emotional stress
- Monitor the progression of nonhematological disorders such as chronic obstructive pulmonary disease, malabsorption syndromes, cancer, and renal disease
- Monitor the response to drugs or chemotherapy, and evaluate undesired reactions to drugs that may cause blood dyscrasias
- Provide screening as part of a complete blood count (CBC) in a general physical examination, especially upon admission to a health care facility or before surgery

RESULT:

Increased in:

MCV Increased in:

- Alcoholism (*Vitamin deficiency related to malnutrition*)
- Antimetabolite therapy (*The therapy inhibits vitamin B₁₂ and folate*)
- Liver disease (*Complex effect on RBCs that includes malnutrition, alterations in RBC shape and size, effects of chronic disease*)
- Pernicious anemia (Vitamin B₁₂/folate anemia)

MCH Increased in:

- Macrocytic anemias (*Related to increased hemoglobin or cell size*)

MCHC Increased in:

- Spherocytosis (*Artifact in measurement caused by abnormal cell shape*)

RDW Increased in:

- Anemias with heterogeneous cell size as a result of hemoglobinopathy, hemolytic anemia, anemia following acute blood loss, iron-deficiency anemia, vitamin- and folate-deficiency anemia (*Related to a mixture of cell sizes as the bone marrow responds to the anemia and/or to a mixture of cell shapes due to cell fragmentation as a result of the disease*)

Decreased in:

MCV Decreased in:

- Iron-deficiency anemia (*Low hemoglobin*)
- Thalassemias (*Low hemoglobin*)

MCH Decreased in:

- Hypochromic anemias (*Low hemoglobin*)
- Microcytic anemias (*Low hemoglobin*)

MCHC Decreased in:

- Iron-deficiency anemia (*The amount of hemoglobin in the RBC is small relative to RBC size*)

RDW Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may decrease the MCHC include styrene (occupational exposure).
- Drugs that may decrease the MCV include nitrofurantoin.
- Drugs that may increase the MCV include colchicine, pentamidine, pyrimethamine, and triamterene.
- Drugs that may increase the MCH and MCHC include oral contraceptives (long-term use).
- Diseases that cause agglutination of RBCs will alter test results.
- Cold agglutinins may falsely increase the MCV and decrease the RBC count. This can be corrected by warming the blood or diluting the sample with warmed saline and then correcting the RBC count mathematically.
- RBC counts can vary depending on the patient's position, decreasing when the patient is recumbent as a result of hemodilution and increasing when the patient rises as a result of hemoconcentration.
- Care should be taken in evaluating the CBC after transfusion.
- Venous stasis can falsely elevate RBC counts; therefore, the tourniquet should not be left on the arm for longer than 60 sec.
- Failure to fill the tube sufficiently (i.e., tube less than three-quarters full) may yield inadequate sample volume for automated analyzers

and may be a reason for specimen rejection.

- Hemolyzed or clotted specimens should be rejected.
- Lipemia and elevated white blood cell (WBC) count (greater than $50 \text{ WBC} \times 10^3/\text{mm}^3$ or $50,000/\text{mm}^3$) will falsely increase the hemoglobin measurement, also affecting the MCV and MCH.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is primarily used to assess RBC shape and size.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's gastrointestinal, hematopoietic, immune, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. An EDTA Microtainer sample may be obtained from infants, children, and adults for whom venipuncture may not be feasible. The specimen should be mixed gently by inverting the tube 10 times. It is stable when stored for up to 6 hr at room temperature or 24 hr if stored refrigerated. In addition, if it is anticipated that the specimen will not be analyzed within 4 to 6 hr, two blood smears should be made immediately after the venipuncture and submitted with the blood sample. Smears made from specimens older than 6 hr will contain an unacceptable number of misleading artifactual abnormalities of the RBCs, such as echinocytes and spherocytes, as well as necrobiotic WBCs.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, complete blood count, complete blood count hematocrit, complete blood count hemoglobin, complete blood count RBC count, complete blood count RBC morphology and inclusions, complete blood count WBC count and differential, erythropoietin, ferritin, folate, Hgb electrophoresis, iron/TIBC, lead, reticulocyte count, sickle cell screen, and vitamin B₁₂.
- ▶ Refer to the Gastrointestinal, Hematopoietic, Immune, and Respiratory System tables at the back of the book for related tests by body system.

Complete Blood Count, RBC Morphology and Inclusions

SYNONYM/ACRONYM: N/A.

SPECIMEN: Whole blood from one full lavender-top (EDTA) tube or Wright's-stained, thin-film peripheral blood smear. The laboratory should be consulted as to the necessity of thick-film smears for the evaluation of malarial inclusions.

REFERENCE VALUE: (Method: Microscopic, manual review of stained blood smear)

Red Blood Cell Morphology	Within Normal Limits	1+	2+	3+	4+
Size					
Anisocytosis	0-5+	5-10	10-20	20-50	Greater than 50
Macrocytes	0-5+	5-10	10-20	20-50	Greater than 50
Microcytes	0-5+	5-10	10-20	20-50	Greater than 50
Shape					
Poikilocytes	0-2+	3-10	10-20	20-50	Greater than 50
Burr cells	0-2+	3-10	10-20	20-50	Greater than 50
Acanthocytes	Less than 1+	2-5	5-10	10-20	Greater than 20
Schistocytes	Less than 1+	2-5	5-10	10-20	Greater than 20
Dacryocytes (teardrop cells)	0-2+	2-5	5-10	20-50	Greater than 20
Codocytes (target cells)	0-2+	2-10	10-20	20-50	Greater than 50
Spherocytes	0-2+	2-10	10-20	20-50	Greater than 50
Ovalocytes	0-2+	2-10	10-20	20-50	Greater than 50
Stomatocytes	0-2+	2-10	10-20	20-50	Greater than 50
Drepanocytes (sickle cells)	Absent	Reported as present or absent			
Helmet cells	Absent	Reported as present or absent			
Agglutination	Absent	Reported as present or absent			
Rouleaux	Absent	Reported as present or absent			
Hemoglobin (Hgb) content					
Hypochromia	0-2+	3-10	10-50	50-75	Greater than 75
Polychromasia					
Adult	Less than 1+	2-5	5-10	10-20	Greater than 20
Newborn	1-6+	7-15	15-20	20-50	Greater than 50
Inclusions					
Cabot rings	Absent	Reported as present or absent			
Basophilic stippling	0-1+	1-5	5-10	10-20	Greater than 20
Howell-Jolly bodies	Absent	1-2	3-5	5-10	Greater than 10
Heinz bodies	Absent	Reported as present or absent			
Hgb C crystals	Absent	Reported as present or absent			
Pappenheimer bodies	Absent	Reported as present or absent			
Intracellular parasites (e.g., Plasmodium, Babesia, Trypanosoma)	Absent	Reported as present or absent			

DESCRIPTION: The decision to manually review a peripheral blood smear for abnormalities in red blood cell (RBC) shape or size is made based on criteria established by the reporting laboratory. Cues in the results of the complete blood count (CBC) will point to specific abnormalities that can be confirmed visually by microscopic review of the sample on a stained blood smear.

INDICATIONS:

- Assist in the diagnosis of anemia
- Detect a hematological disorder, neoplasm, or immunological abnormality
- Determine the presence of a hereditary hematological abnormality
- Monitor the effects of physical or emotional stress on the patient
- Monitor the progression of non-hematological disorders, such as chronic obstructive pulmonary disease, malabsorption syndromes, cancer, and renal disease
- Monitor the response to drugs or chemotherapy, and evaluate undesired reactions to drugs that may cause blood dyscrasias
- Provide screening as part of a CBC in a general physical examination, especially upon admission to a health care facility or before surgery

RESULT:

Red Blood Cell Size

Increased in:

Cell size increased in:

- Alcoholism
- Aplastic anemia
- Chemotherapy
- Chronic hemolytic anemia
- Grossly elevated glucose (hyperosmotic)
- Hemolytic disease of the newborn

- Hypothyroidism
- Leukemia
- Lymphoma
- Metastatic carcinoma
- Myelofibrosis
- Myeloma
- Refractory anemia
- Sideroblastic anemia
- Vitamin B₁₂/folate deficiency

Decreased in:

Cell size decreased in:

- Hemoglobin C disease
- Hemolytic anemias
- Hereditary spherocytosis
- Inflammation
- Iron-deficiency anemia
- Thalassemias

Red Blood Cell Shape

Variations in cell shape are the result of hereditary conditions such as elliptocytosis, sickle cell anemia, spherocytosis, thalassemias, or hemoglobinopathies (e.g., hemoglobin C disease). Irregularities in cell shape can also result from acquired conditions, such as physical/mechanical cellular trauma, exposure to chemicals, or reactions to medications.

- Acquired spherocytosis can result from Heinz body hemolytic anemia, microangiopathic hemolytic anemia, secondary isoimmunohemolytic anemia, and transfusion of old banked blood.
- Acanthocytes are associated with acquired conditions such as alcoholic cirrhosis with hemolytic anemia, disorders of lipid metabolism, hepatitis of newborns, malabsorptive diseases, metastatic liver disease, the postsplenectomy period, and pyruvate kinase deficiency.
- Burr cells are commonly seen in acquired renal insufficiency, burns, cardiac valve disease, disseminated intravascular coagulation (DIC), hypertension, intravenous fibrin deposition, metastatic malignancy, normal neonatal period, and uremia.

- Codocytes are seen in hemoglobinopathies, iron-deficiency anemia, obstructive liver disease, and the postsplenectomy period.
- Dacryocytes are most commonly associated with metastases to the bone marrow, myelofibrosis, myeloid metaplasia, pernicious anemia, and tuberculosis.
- Schistocytes are seen in burns, cardiac valve disease, DIC, glomerulonephritis, hemolytic anemia, microangiopathic hemolytic anemia, renal graft rejection, thrombotic thrombocytopenic purpura, uremia, and vasculitis.

Red Blood Cell Hemoglobin Content

RBCs with a normal hemoglobin (Hgb) level have a clear central pallor and are referred to as *normochromic*.

- Cells with low Hgb and lacking in central pallor are referred to as *hypochromic*. Hypochromia is associated with iron-deficiency anemia, thalassemias, and sideroblastic anemia.
- Cells with excessive Hgb levels are referred to as *hyperchromic*, even though they technically lack a central pallor. Hyperchromia is usually associated with an elevated mean corpuscular Hgb concentration as well as hemolytic anemias.
- Cells referred to as *polychromic* are young erythrocytes that still contain ribonucleic acid (RNA). The RNA is picked up by the Wright's stain. Polychromasia is indicative of premature release of RBCs from bone marrow secondary to increased erythropoietin stimulation.

Red Blood Cell Inclusions

RBC inclusions can result from certain types of anemia, abnormal Hgb precipitation, or parasitic infection.

- Cabot rings may be seen in megaloblastic and other anemias, lead poisoning, and conditions in

which RBCs are destroyed before they are released from bone marrow.

- Basophilic stippling is seen whenever there is altered Hgb synthesis, as in thalassemias, megaloblastic anemias, alcoholism, and lead or arsenic intoxication.
- Howell-Jolly bodies are seen in sickle cell anemia, other hemolytic anemias, megaloblastic anemia, congenital absence of the spleen, and the postsplenectomy period.
- Pappenheimer bodies may be seen in cases of sideroblastic anemia, thalassemias, refractory anemia, dyserythropoietic anemias, hemosiderosis, and hemochromatosis.
- Heinz bodies are most often seen in the blood of patients who have ingested drugs known to induce the formation of these inclusion bodies. They are also seen in patients with hereditary glucose-6-phosphate dehydrogenase (G6PD) deficiency.
- Hgb C crystals can often be identified in stained peripheral smears of patients with hereditary hemoglobin C disease.
- Parasites such as *Plasmodium* (transmitted by mosquitoes and causing malaria) and *Babesia* (transmitted by ticks), known to invade human RBCs, can be visualized with Wright's stain and other special stains of the peripheral blood.

CRITICAL VALUES:

The presence of sickle cells or parasitic inclusions should be brought to the immediate attention of the requesting health care provider (HCP).

INTERFERING FACTORS:

- Drugs and substances that may increase Heinz body formation as an initial precursor to significant hemolysis include acetanilid,

acetylsalicylic acid, aminopyrine, antimalarials, antipyretics, furadaltone, furazolidone, methylene blue, naphthalene, and nitrofurans.

- Care should be taken in evaluating the CBC after transfusion.
- Leaving the tourniquet in place for longer than 60 sec can falsely affect the results.
- Morphology can be evaluated to some extent via indices; therefore, failure to fill the tube sufficiently (i.e., tube less than three-quarters full) may yield inadequate sample volume for automated analyzers and may be a reason for specimen rejection.
- Hemolyzed or clotted specimens should be rejected.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess red blood cell appearance.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, gastrointestinal, hematopoietic, hepatobiliary, immune, musculoskeletal, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support

before, during, and after the procedure.

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. An EDTA Microtainer sample may be obtained from infants, children, and adults for whom venipuncture may not be feasible. The specimen should be mixed gently by inverting the tube 10 times. The specimen should be analyzed within 6 hr when stored at room temperature or within 24 hr if stored at refrigerated temperature. If it is anticipated the specimen will not be analyzed within 4 to 6 hr, two blood smears should be made immediately after the venipuncture and submitted with the blood sample. Smears made from specimens older than 6 hr will contain an unacceptable number of misleading artifactual abnormalities of the RBCs, such as echinocytes and spherocytes, as well as necrobiotic white blood cells.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ *Nutritional considerations*: Instruct patients to consume a variety of foods

within the basic food groups, maintain a healthy weight, be physically active, limit salt intake, limit alcohol intake, and avoid the use of tobacco.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count, d-aminolevulinic acid, biopsy bone marrow, erythropoietin, ferritin, G6PD, complete blood count hemocrit, complete blood count hemoglobin, hemoglobin electrophoresis, iron/TIBC, lead, complete blood count platelet count, complete blood count RBC count, complete blood count RBC indices, reticulocyte count, and complete blood count WBC count with differential.
- ▶ Refer to the Cardiovascular, Gastrointestinal, Hematopoietic, Hepatobiliary, Immune, Musculoskeletal, and Respiratory System tables at the back of the book for related tests by body system.

Complete Blood Count, WBC Count and Differential

SYNONYM/ACRONYM: WBC with diff, leukocyte count, white cell count.

SPECIMEN: Whole blood from one full lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Automated, computerized, multichannel analyzers that sort and size cells on the basis of changes in either electrical impedance or light pulses as the cells pass in front of a laser. Many of these analyzers are capable of determining a five-part WBC differential.) The WBC count and differential enumerates and identifies granulocytes, lymphocytes, monocytes, eosinophils, and basophils.

Age	Conventional Units WBC × 10 ³ /mm ³ *	Neutrophils		
		Total Neutrophils (Absolute) and %	Bands (Absolute) and %	Segments (Absolute) and %
Birth	9.0–30.0	(5.5–18.3) 61%	(0.8–2.7) 9.1%	(4.7–15.6) 52%
1 to 23 mo	6.0–17.5	(1.9–5.4) 31%	(0.2–0.5) 3.1%	(1.7–4.9) 28%
2–10 y	4.5–13.5	(2.4–7.3) 54%	(0.1–0.4) 3.0%	(2.3–6.9) 51%
11 y–Adult	4.5–11.0	(2.7–6.5) 59%	(0.1–0.3) 3.0%	(2.5–6.2) 56%

*SI Units (Conventional Units × 1 × 10⁹/L or WBC × 1000/mm³)

DESCRIPTION: White blood cells (WBCs) constitute the body's primary defense system against foreign organisms, tissues, and other substances. The life span of a normal WBC is 13 to 20 days. Old WBCs are destroyed by the lymphatic system and excreted in the feces. Reference values for WBC counts vary significantly with age. WBC counts vary diurnally, with counts being lowest in the morning and highest in the late afternoon. Other variables such as stress and high levels of activity or physical exercise can trigger transient increases of 2000 to 5000 mm³. The main WBC types are neutrophils (band and segmented neutrophils), eosinophils, basophils, monocytes, and lymphocytes. WBCs are produced in the bone marrow. B cell lymphocytes remain in the bone marrow to mature. T cell lymphocytes migrate to and mature in the thymus. The WBC count can be performed alone with the differential cell count or as part of the complete blood count (CBC). The WBC differential can be performed by an automated instrument or manually on a slide prepared from a stained peripheral blood sample. Automated instruments provide excellent, reliable information but the accuracy of the WBC count can be affected by the presence of circulating nucleated red blood cells, clumped platelets, fibrin strands, cold agglutinins, cryo-

globulins, intracellular parasitic organisms, or other significant blood cell inclusions and may not be identified in the interpretation of an automated blood count. The decision to report a manual or automated differential is based on specific criteria established by the laboratory. The criteria are designed to identify findings that warrant further investigation or confirmation by manual review. An increased WBC count is termed *leukocytosis*, and a decreased WBC count is termed *leukopenia*. A total WBC count indicates the degree of response to a pathological process, but a more complete evaluation for specific diagnoses for any one disorder is provided by the differential count. The WBCs in the count and differential are reported as an *absolute value* and as a percentage. The relative percentages of cell types are arrived at by basing the enumeration of each cell type on a 100-cell count. The absolute value is obtained by multiplying the relative percentage value of each cell type by the total WBC count. For example, on a CBC report, with a total WBC of 9×10^9 and WBC differential with 92% segmented neutrophils, 1% band neutrophils, 5% lymphocytes, and 1% monocytes the absolute values are calculated as follows. $92/100 \times 9 = 8.3$ segs, $1/100 \times 9 = 0.1$ bands, $5/100 \times 9 = 0.45$ lymphs,

	Lymphocytes (Absolute) and %	Monocytes (Absolute) and %	Eosinophils (Absolute) and %	Basophils (Absolute) and %
Birth	(2.8–9.3) 31%	(0.5–1.7) 5.8%	(0.02–0.7) 2.2%	(0.1–0.2) 0.6%
1 to 23 mo	(3.7–10.7) 61%	(0.3–0.8) 4.8%	(0.2–0.5) 2.6%	(0–0.1) 0.5%
2–10 yr	(1.7–5.1) 38%	(0.2–0.6) 4.3%	(0.1–0.3) 2.4%	(0–0.1) 0.5%
11 yr–adult	(1.5–3.7) 34%	(0.2–0.4) 4.0%	(0.05–0.5) 2.7%	(0–0.1) 0.5%

$1/100 \times 9 = 0.1$ monos for a total of 9.0 WBC count.

Acute leukocytosis is initially accompanied by changes in the WBC count population, followed by changes within the individual WBCs. Leukocytosis usually occurs by way of increase in a single WBC family rather than a proportional increase in all cell types. Toxic granulation and vacuolation are commonly seen in leukocytosis accompanied by a *shift to the left*, or increase in the percentage of immature band neutrophils to mature segmented neutrophils. Bandemia is defined by the presence of greater than 6% band neutrophils in the total neutrophil cell population. These changes in the white cell population are most commonly associated with an infectious process, usually bacterial, but they can occur in healthy individuals who are under stress (in response to epinephrine production), such as women in childbirth and very young infants. The WBC count and differential of a woman in labor or of an actively crying infant may show an overall increase in WBCs with a shift to the left. Before initiating any kind of intervention, it is important to determine whether an increased WBC count is the result of a normal condition involving physiological stress or a pathological process. The use of multiple specimen types may confuse the interpretation of results in infants. Multiple samples from the same collection site (i.e., capillary versus venous) may be necessary to obtain an accurate assessment of the WBC picture in these young patients.

Neutrophils are normally found as the predominant WBC type in the circulating blood. Also called *polymorphonuclear cells*, they are the body's first line of

defense through the process of phagocytosis. They also contain enzymes and pyogens, which combat foreign invaders.

Lymphocytes are agranular, mono-nuclear blood cells that are smaller than granulocytes. They are found in the next highest percentage in normal circulation. Lymphocytes are classified as B cells and T cells. Both types are formed in the bone marrow, but B cells mature in the bone marrow and T cells mature in the thymus. Lymphocytes play a major role in the body's natural defense system. B cells differentiate into immunoglobulin-synthesizing plasma cells. T cells function as cellular mediators of immunity and comprise helper/inducer (CD4) lymphocytes, delayed hypersensitivity lymphocytes, cytotoxic (CD8 or CD4) lymphocytes, and suppressor (CD8) lymphocytes.

Monocytes are mononuclear cells similar to lymphocytes, but they are related more closely to granulocytes in terms of their function. They are formed in the bone marrow from the same cells as those that produce neutrophils. The major function of monocytes is phagocytosis. Monocytes stay in the peripheral blood for about 70 hr, after which they migrate into the tissues and become macrophages.

The function of eosinophils is phagocytosis of antigen-antibody complexes. They become active in the later stages of inflammation. Eosinophils respond to allergic and parasitic diseases: They have granules that contain histamine used to kill foreign cells in the body and proteolytic enzymes that damage parasitic worms (see monograph titled "Eosinophil Count").

Basophils are found in small numbers in the circulating blood. They have a phagocytic function and, similar to eosinophils, contain numerous specific granules. Basophilic granules contain heparin, histamines, and serotonin. Basophils may also be found in tissue and as such are classified as mast cells. Basophilia is noted in conditions such as leukemia, Hodgkin's disease, polycythemia vera, ulcerative colitis, nephrosis, and chronic hypersensitivity states.

INDICATIONS:

- Assist in confirming suspected bone marrow depression
- Assist in determining the cause of an elevated WBC count (e.g., infection, inflammatory process)
- Detect hematological disorder, neoplasm, or immunological abnormality
- Determine the presence of a hereditary hematological abnormality
- Monitor the effects of physical or emotional stress
- Monitor the progression of non-hematological disorders, such as chronic obstructive pulmonary disease, malabsorption syndromes, cancer, and renal disease
- Monitor the response to drugs or chemotherapy, and evaluate undesired reactions to drugs that may cause blood dyscrasias
- Provide screening as part of a CBC in a general physical examination, especially on admission to a health care facility or before surgery

RESULT:

Increased in:

Increased in (leukocytosis):

- Normal physiological and environmental conditions:
Early infancy (*Increases are believed to be related to the physiological stress of birth and metabolic demands of rapid development*)

Emotional stress (*Due to secretion of epinephrine*)

Exposure to extreme heat or cold (*Physiological stress*)

Pregnancy and labor (*WBC counts may be modestly elevated, due to increased neutrophils, into the third trimester and during labor; returning to normal within a week postpartum*)

Strenuous exercise (*Due to epinephrine secretion; increases are short in duration, minutes to hours*)

Ultraviolet light (*Physiological stress and possible inflammatory response*)

- Pathological conditions:
Acute hemolysis, especially due to splenectomy or transfusion reactions (*Leukocytes respond to remove lysed RBC fragments*)
All types of infections (*inflammatory or infectious response*)
Anemias (*Bone marrow disorders affecting RBC production may result in elevated WBC count*)
Appendicitis (*Inflammatory or infectious response*)
Collagen disorders (*Inflammatory response*)
Cushing's disease (*Overproduction of cortisol, a corticosteroid, stimulates WBC production*)
Inflammatory disorders (*Inflammatory or infectious response*)
Leukemias and other malignancies (*Bone marrow disorders that result in abnormal WBC production*)
Parasitic infestations (*Inflammatory or infectious response*)
Polycythemia vera (*Myeloproliferative bone marrow disorder causing an increase in all cell lines*)

Decreased in:

Decreased in (leukopenia):

- Normal physiological conditions:
Diurnal rhythms (lowest in the morning)
- Pathological conditions:
Alcoholism (*WBC changes associated with nutritional deficiencies of vitamin B₁₂ or folate*)
Anemias (*WBC changes associated with nutritional deficiencies of*

vitamin B₁₂ or folate, especially in megaloblastic anemias)

Bone marrow depression (*Due to decreased production*)

Malaria (*Due to hypersplenism*)

Malnutrition (*WBC changes associated with nutritional deficiencies of vitamin B₁₂ or folate*)

Radiation (*Physical destruction due to toxic effects of radiation*)

Rheumatoid arthritis (*Side effect of medications used to treat the condition*)

Systemic lupus erythematosus (SLE) and other autoimmune disorders (*Side effect of medications used to treat the condition*)

Toxic and antineoplastic drugs (*Bone marrow suppression*)

Very low birth weight neonates (*Bone marrow activity is diverted to develop RBCs in response to hypoxia*)

Viral infections (*Leukopenia, lymphocytopenia, and abnormal lymphocytes may be present in the early stages of viral infections*)

Neutrophils increased (neutrophilia):

- Acute hemolysis
- Acute hemorrhage
- Extremes in temperature
- Infectious diseases
- Inflammatory conditions (rheumatic fever, gout, rheumatoid arthritis, vasculitis, myositis)
- Malignancies
- Metabolic disorders (uremia, eclampsia, diabetic ketoacidosis, thyroid storm, Cushing's syndrome)
- Myelocytic leukemia
- Physiological stress (e.g., allergies, asthma, exercise, childbirth, surgery)
- Tissue necrosis (burns, crushing injuries, abscesses, myocardial infarction)
- Tissue poisoning with toxins and venoms

Neutrophils decreased (neutropenia):

- Acromegaly
- Addison's disease

- Anaphylaxis
- Anorexia nervosa, starvation, malnutrition
- Bone marrow depression (viruses, toxic chemicals, overwhelming infection, radiation, Gaucher's disease)
- Disseminated SLE
- Thyrotoxicosis
- Viral infection (mononucleosis, hepatitis, influenza)
- Vitamin B₁₂ or folate deficiency

Lymphocytes increased (lymphocytosis):

- Addison's disease
- Felty's syndrome
- Infections
- Lymphocytic leukemia
- Lymphomas
- Lymphosarcoma
- Myeloma
- Ricketts
- Thyrotoxicosis
- Ulcerative colitis
- Waldenström's macroglobulinemia

Lymphocytes decreased (lymphopenia):

- Antineoplastic drugs
- Aplastic anemia
- Bone marrow failure
- Burns
- Gaucher's disease
- Hemolytic disease of the newborn
- High doses of adrenocorticosteroids
- Hodgkin's disease
- Hypersplenism
- Immunodeficiency diseases
- Malnutrition
- Pernicious anemia
- Pneumonia
- Radiation
- Rheumatic fever
- Septicemia
- Thrombocytopenic purpura
- Toxic chemical exposure
- Transfusion reaction

Monocytes increased (monocytosis):

- Carcinomas
- Cirrhosis

- Collagen diseases
- Gaucher's disease
- Hemolytic anemias
- Hodgkin's disease
- Infections
- Lymphomas
- Monocytic leukemia
- Polycythemia vera
- Radiation
- Sarcoidosis
- SLE
- Thrombocytopenic purpura
- Ulcerative colitis

CRITICAL VALUES:

Less than $2.5 \text{ WBC} \times 10^3/\text{mm}^3$ or $2500 \text{ WBC}/\text{mm}^3$

Greater than $30.0 \text{ WBC} \times 10^3/\text{mm}^3$ or $30,000 \text{ WBC}/\text{mm}^3$

Note and immediately report to the requesting health care provider (HCP) any critically increased or decreased values and related symptoms. The presence of abnormal cells, other morphological characteristics, or cellular inclusions may signify a potentially life-threatening or serious health condition and should be investigated. Examples are hypersegmented neutrophils, agranular neutrophils, blasts or other immature cells, Auer rods, Döhle bodies, marked toxic granulation, or plasma cells.

INTERFERING FACTORS:

- Drugs that may decrease the overall WBC count include acetyldigitoxin, acetylsalicylic acid, aminoglutethimide, aminopyrine, aminosalicic acid, ampicillin, amsacrine, antazoline, anticonvulsants, antineoplastic agents (therapeutic intent), antipyrene, barbiturates, busulfan, carbutamide, carmustine, chlorambucil, chloramphenicol, chlordane, chlorophenothane, chlortetracycline, chlorthalidone, cisplatin, colchicine, colistimethate, cycloheximide, cyclophosphamide, cytarabine,

dacarbazine, dactinomycin, diaprism, diazepam, diethylpropion, digitalis, dipyridamole, dipyrone, fumagillin, glaucarubin, glucosulfone, hexachlorobenzene, hydroflumethiazide, hydroxychloroquine, iothiouracil, iproniazid, lincomycin, local anesthetics, mefenamic acid, mepazine, meprobamate, mercaptopurine, methotrexate, methylpromazine, mitomycin, paramethadione, parathion, penicillin, phenacemide, phenindione, phenothiazine, pipamazine, prednisone (by Coulter S method), primaquine, procainamide, procarbazine, prochlorperazine, promazine, promethazine, pyrazolones, quinacrine, quinines, radioactive compounds, razoxane, ristocetin, sulfa drugs, tamoxifen, tetracycline, thenalidine, thioridazine, tolazamide, tolazoline, tolbutamide, trimethadione, and urethane.

- A significant decrease in basophil count occurs rapidly after intravenous injection of propanidid and thiopental.
- A significant decrease in lymphocyte count occurs rapidly after administration of corticotropin, mechlorethamine, methylsergide, and x-ray therapy; and after megadoses of niacin, pyridoxine, and thiamine.
- Drugs that may increase the overall WBC count include amphetamine, amphotericin B, chloramphenicol, chloroform (normal response to anesthesia), colchicine (leukocytosis follows leukopenia), corticotropin, erythromycin, ether (normal response to anesthesia), fluroxene (normal response to anesthesia), isoflurane (normal response to anesthesia), niacinamide, phenylbutazone, prednisone, and quinine.
- Drug allergies may have a significant effect on eosinophil count and may affect the overall WBC count. "Refer to the monograph

titled “Eosinophil Count” for a detailed listing of interfering drugs.

- The WBC count may vary depending on the patient's position, decreasing when the patient is recumbent owing to hemodilution and increasing when the patient rises owing to hemoconcentration.
- Venous stasis can falsely elevate results; the tourniquet should not be left on the arm for longer than 60 sec.
- Failure to fill the tube sufficiently (i.e., tube less than three-quarters full) may yield inadequate sample volume for automated analyzers and may be reason for specimen rejection.
- Hemolyzed or clotted specimens should be rejected for analysis.
- The presence of nucleated red blood cells or giant or clumped platelets affects the automated WBC, requiring a manual correction of the WBC count.
- Care should be taken in evaluating the CBC during the first few hours after transfusion.
- Patients with cold agglutinins or monoclonal gammopathies may have a falsely decreased WBC count as a result of cell clumping.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Inform the patient that the test is primarily used to evaluate viral and bacterial infections and to diagnose and monitor leukemic disorders.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic, immune, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. The specimen should be mixed gently by inverting the tube 10 times. It is stable when stored for up to 6 hr at room temperature or 24 hr if stored refrigerated. In addition, if it is anticipated that the specimen will not be analyzed within 4 to 6 hr, two blood smears should be made immediately after the venipuncture and submitted with the blood sample.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Infection, fever, sepsis, and trauma can result in an impaired nutritional status. Malnutrition can occur for many reasons, including fatigue, lack of appetite, and gastrointestinal distress.

- ▶ **Nutritional considerations:** Adequate intake of vitamins A and C are also important for regenerating body stores depleted by the effort exerted in fighting infections. Educate the patient or caregiver regarding the importance of following the prescribed diet.
- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the National Cancer Institute (www.nci.nih.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include albumin, antibody, anti-neutrophilic cytoplasmic biopsy bone marrow, biopsy lymph node, complete blood count, culture bacterial (see individually listed culture monographs), culture fungal, culture viral, eosinophil count, ESR, fecal analysis, gram stain, infectious mononucleosis, LAP, complete blood count RBC count, complete blood count RBC indices, complete blood count RBC morphology, UA, and WBC scan.
- ▶ Refer to the Hematopoietic, Immune, and Respiratory System tables at the back of the book for related tests by body system.

C

Computed Tomography, Abdomen

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), abdominal CT, helical/spiral CT.

AREA OF APPLICATION: Abdomen.

CONTRAST: With or without oral or IV iodinated contrast medium.

DESCRIPTION: Abdominal computed tomography (CT) is a noninvasive procedure used to enhance certain anatomic views of the abdominal structures. It becomes invasive when contrast medium is used. During the procedure the patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated elec-

tronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion. Differences in tissue density are detected and recorded, and are viewable as computerized digital images. Slices or thin sections of certain anatomic views of the liver, biliary tract, pancreas, kidneys,

spleen, intestines, and vascular system are reviewed to allow differentiations of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas and aneurysms. The procedure is repeated after intravenous injection of iodinated contrast medium for vascular evaluation or after oral ingestion of contrast medium for evaluation of bowel and adjacent structures. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning is used to produce a series of moving images of the area scanned. The CT scan can be used to guide biopsy needles into areas of abdominal tumors to obtain tissue for laboratory analysis and to guide placement of catheters for drainage of intra-abdominal abscesses. Tumors, before and after therapy, may be monitored with CT scanning.

INDICATIONS:

- Assist in differentiating between benign and malignant tumors
- Detect aortic aneurysms
- Detect tumor extension of masses and metastasis into the abdominal area
- Differentiate aortic aneurysms from tumors near the aorta
- Differentiate between infectious and inflammatory processes
- Evaluate cysts, masses, abscesses, renal calculi, gastrointestinal (GI) bleeding and obstruction, and trauma
- Evaluate retroperitoneal lymph nodes
- Monitor and evaluate the effectiveness of medical, radiation, or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and shape of abdominal organs and vascular system

Abnormal findings in:

- Abdominal abscess
- Abdominal aortic aneurysm
- Adrenal tumor or hyperplasia
- Appendicitis
- Dilation of the common hepatic duct, common bile duct, or gallbladder
- Hematomas, diverticulitis, gallstones
- Hemoperitoneum
- Hepatic cysts or abscesses
- Pancreatic pseudocyst
- Primary and metastatic neoplasms
- Renal calculi, bowel perforation, and GI bleeding and obstruction
- Splenic laceration, tumor, infiltration, and trauma


CRITICAL VALUES:

- Abscess
- Acute GI bleed
- Aortic aneurysm
- Appendicitis
- Aortic dissection
- Bowel perforation
- Bowel obstruction
- Mesenteric torsion
- Tumor with significant mass effect
- Visceral injury; significant solid organ laceration



Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium

may benefit from premedication with corticosteroids or the use of nonionic contrast medium.

- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the GI tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiologic procedure
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and cause unclear images
- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure may include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting

preparations may cause the procedure to be canceled or repeated.

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses abdominal organs.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ♦ Obtain a history of the patient's GI, hepatobiliary, and genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ♦ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium

Ensure that barium studies were performed more than 4 days before the CT scan.

- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Explain the purpose of the test and how the procedure is performed. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is performed in a radiology suite usually by a HCP and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium, if given.
- ▶ The patient may be requested to drink approximately 450 mL of a dilute barium solution (approximately 1% barium) beginning 1 hr before the examination. This is administered to distinguish GI organs from the other abdominal organs.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.

▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.

▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluids, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast, emergency drugs, and sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast media is used, during and after injection a rapid series of images is taken.

- ◆ Instruct the patient to inhale deeply and hold his or her breathe while the x-ray images are taken, and then to exhale after the images are taken.
- ◆ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ◆ The needle is removed, and a pressure dressing is applied over the puncture site.
- ◆ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
 - ◆ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
 - ◆ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
 - ◆ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
 - ◆ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ◆ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
 - ◆ Instruct the patient to apply cold compresses to the insertion site as needed, to reduce discomfort or edema.
 - ◆ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
 - ◆ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.
 - ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ACTH and challenge tests, amylase, angiography abdomen, biopsy intestinal, BUN, calculus kidney stone panel, cortisol and challenge tests, creatinine, cystoscopy, hepatobiliary scan, IVP, KUB studies, MRI abdomen, peritoneal fluid analysis, renogram, and US pelvis.
- ◆ Refer to the Gastrointestinal, Hepatobiliary and Genitourinary System tables at the back of the book for related tests by body system.

Computed Tomography, Angiography

SYNONYM/ACRONYM: Computed axial tomography (CAT) angiography, CTA.

AREA OF APPLICATION: Vessels.

CONTRAST: IV iodinated contrast medium.

DESCRIPTION: Computed tomography angiography (CTA) is a non-invasive procedure that enhances certain anatomic views of vascular structures. This procedure complements traditional angiography and allows reconstruction of the images in different planes and removal of surrounding structures, leaving only the vessels to be studied. While lying on a table, the patient moves in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion by detecting and recording differences in tissue density after having an x-ray beam passed through the tissues. CTA uses spiral CT technology and collects large amounts of data with each scan. Retrospectively, the data can be manipulated to produce the desired image without exposure to additional radiation or contrast medium. Multiplanar reconstruction images are reviewed by the health care provider (HCP) at a computerized workstation. These images are helpful when there are heavily calcified vessels. The axial images give the most precise information regarding the true extent of stenosis, and they can also evaluate intracerebral

aneurysms. Small ulcerations and plaque irregularity are readily seen with CTA; the degree of stenosis can be estimated better with CTA because of the increased number of imaging planes. Density measurements are sent to a computer that produces a digital image of the anatomy, enabling the HCP to look at slices or thin sections of certain anatomic views of the vessels. Iodinated contrast medium is given IV for vascular evaluation. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data.

INDICATIONS:

- Detect aneurysms
- Detect embolism or other occlusions
- Detect fistula
- Detect stenosis
- Detect vascular disease
- Differentiate aortic aneurysms from tumors near the aorta
- Differentiate between vascular and nonvascular tumors
- Evaluate atherosclerosis
- Evaluate hemorrhage or trauma
- Monitor and evaluate the effectiveness of medical or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and shape of vascular structures

Abnormal findings in:




- Aortic aneurysm
- Cysts or abscesses
- Emboli
- Hemorrhage
- Neoplasm
- Occlusion
- Shunting
- Stenosis

CRITICAL VALUES:

- Brain or spinal cord ischemia
- Emboli
- Hemorrhage
- Leaking aortic aneurysm
- Occlusion
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with the HCP should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the cardiovascular system.
- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ▶ Obtain a history of patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of

discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives.
- ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
- ▶ Instruct the patient to remove all external metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.

- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast, emergency drugs, and sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ The contrast medium is injected, and a rapid series of images is taken during and after the filling of the vessels to be examined. Delayed images may be taken to examine the vessels after a time and to monitor the venous phase of the procedure.
- ▶ Ask the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure. Monitor and administer an antiemetic agent if ordered. Ready an emesis basin for use.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ The needle or vascular catheter is removed and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume pretest diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every

4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.

- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting. Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Assess extremities for signs of ischemia or absence of distal pulse caused by a catheter-induced thrombus.
- ▶ Instruct the patient in the care and assessment of the site and to observe for bleeding, hematoma formation, bile leakage, and inflammation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the

prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.

- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include angiography of the specific area (abdomen, adrenal, carotid, coronary, pulmonary, renal),

blood pool imaging, BUN, chest x-ray, colonoscopy, CT of the specific area (abdomen, biliary/liver, brain, pituitary, renal, spine, spleen, thoracic), creatinine echocardiography, echocardiography transesophageal, fluorescein angiography, fundus photography, MRA, MRI of the specific area (abdomen, brain, chest, pituitary), MI scan, plethysmography, PET (brain, heart), proctosigmoidoscopy, US carotid, and US venous Doppler extremity.

- Refer to the Cardiovascular System table at the back of the book for related tests by body system.

Computed Tomography, Biliary Tract and Liver

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), abdominal CT, helical/spiral CT.

AREA OF APPLICATION: Liver, biliary tract, and adjacent structures.

CONTRAST: With or without IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) of the liver and biliary tract is a noninvasive procedure that enhances certain anatomic views of these structures. It becomes invasive with the use of contrast medium. During the procedure the patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion. Differences in tissue density are detected and recorded, and are viewable as computerized

digital images. Slices or thin sections of certain anatomic views of the kidneys and associated vascular system are reviewed to allow differentiation of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas and aneurysms. The procedure is repeated after IV injection of iodinated contrast medium for vascular evaluation or after oral ingestion of contrast medium for evaluation of bowel and adjacent structures. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning produces a series of moving images of the scanned

area. The CT scan can be used to guide biopsy needles into areas of liver and biliary tract masses to obtain tissue for laboratory analysis and for placement of needles to aspirate cysts or abscesses. CT scanning can monitor mass, cyst, or tumor growth and post-therapy response.

INDICATIONS:

- Assist in differentiating between benign and malignant tumors
- Detect dilation or obstruction of the biliary ducts with or without calcification or gallstone
- Detect liver abnormalities, such as cirrhosis with ascites and fatty liver
- Detect tumor extension of masses and metastasis into the hepatic area
- Differentiate aortic aneurysms from tumors near the aorta
- Differentiate between obstructive and nonobstructive jaundice
- Differentiate infectious from inflammatory processes
- Evaluate hepatic cysts, masses, abscesses, and hematomas, or hepatic trauma
- Monitor and evaluate effectiveness of medical, radiation, or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and contour of the liver and biliary ducts




Abnormal findings in:

- Dilation of the common hepatic duct, common bile duct, or gallbladder
- Gallstones
- Hematomas
- Hepatic cysts or abscesses
- Jaundice (obstructive or nonobstructive)
- Primary and metastatic neoplasms

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye.
The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the liver, biliary tract, and adjacent structures.
- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of results of the patient's GI, hepatobiliary and genitourinary systems, symptoms, and previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives.

- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium, if given.
- ▶ The patient may be requested to drink approximately 450 mL of a dilute barium solution (approximately 1% barium) beginning 1 hr before the examination. This is administered to distinguish GI organs from the other abdominal organs.
- ▶ Instruct the patient to remove all external metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluids, and medication restrictions and pretesting preparations for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast medium, emergency drugs, and sedatives.
- ▶ Administer an anti-anxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast medium is used, a rapid series of images is taken during and after injection.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.

- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the insertion site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast media.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further

testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, AST, bilirubin, biopsy liver, BUN, creatinine, GGT, hepatobiliary scan, KUB, liver and spleen scan, MRI abdomen, PT/INR, and US liver.
- ▶ Refer to the Gastrointestinal, Hepatobiliary, and Genitourinary System tables at the back of the book for related tests by body system.

Computed Tomography, Brain

SYNONYM/ACRONYM: Computed axial tomography (CAT) of the head, computed transaxial tomography (CTT) of the head, brain CT, helical/spiral CT.

AREA OF APPLICATION: Brain.

CONTRAST: With or without IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) of the brain is a noninvasive procedure used to assist in diagnosing abnormalities of the head, brain tissue, cerebrospinal fluid, and blood circulation. It becomes invasive if contrast medium is used. The patient lies on a table and is

moved in and out of a doughnut-like device called a gantry, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion.

Differences in tissue density are detected and recorded, and are viewable as computerized digital images for the health care provider (HCP) to look at. Slices or thin sections of certain anatomic views of the brain and associated vascular system are viewed to allow differentiations of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas or aneurysms. The procedure is repeated after intravenous injection of iodinated contrast medium for vascular evaluation. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning is used to produce a series of moving images of the area scanned. Tumor progression, before and after therapy, and effectiveness of medical interventions may be monitored by CT scanning.

INDICATIONS:

- Detect brain infection, abscess, or necrosis, as evidenced by decreased density on the image
- Detect ventricular enlargement or displacement by increased cerebrospinal fluid
- Determine benign and cancerous intracranial tumors and cyst formation, as evidenced by changes in tissue densities
- Determine cause of increased intracranial pressure
- Determine presence and type of hemorrhage in infants and children experiencing signs and symptoms of intracranial trauma, or congenital conditions such as hydrocephalus and arteriovenous malformations (AVMs)
- Determine presence of multiple sclerosis, as evidenced by sclerotic plaques
- Determine lesion size and location causing infarct or hemorrhage
- Differentiate hematoma location after trauma (e.g., subdural, epidural, cerebral), and determine extent of edema, as evidenced by higher blood densities
- Differentiate between cerebral infarction and hemorrhage
- Evaluate abnormalities of the middle ear ossicles, auditory nerve, and optic nerve
- Monitor and evaluate the effectiveness of medical, radiation, or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and shape of intracranial structures and vascular system

Abnormal findings in:




- Abscess
- Aneurysm
- AVMs
- Cerebral atrophy
- Cerebral edema
- Cerebral infarction
- Congenital abnormalities
- Craniopharyngioma
- Cysts
- Hematomas (e.g., epidural, subdural, intracerebral)
- Hemorrhage
- Hydrocephaly
- Increased intracranial pressure or trauma
- Infection
- Sclerotic plaques suggesting multiple sclerosis
- Tumor
- Ventricular or tissue displacement or enlargement

CRITICAL VALUES:

- Abscess
- Acute hemorrhage
- Aneurysm
- Infarction
- Infection
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, dentures, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment

- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure may include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with the HCP should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- Inform the patient that the procedure assesses the brain.
- Obtain a history of the patient's complaints or clinical symptoms, including

a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.

- ▶ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast media is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 15 to 30 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually contrast medium and normal saline are infused.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium.
- ▶ Instruct the patient to remove dentures and jewelry and other metallic objects from the area to be examined.
- ▶ There are no food or fluid restrictions unless by medical direction. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with medication restrictions and pretesting preparations.
- ▶ Ensure the patient has removed dentures and all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast medium, emergency drugs, and sedatives.

- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast media is used, a rapid series of images is taken during and after injection.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
 - ▶ Instruct the patient to resume medications and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
 - ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
 - ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
 - ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
 - ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
 - ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
 - ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.
 - ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography carotids, BUN, CSF analysis, CT angiography, creatinine, EEG, EMG, MR angiography, and MRI brain, PET brain.
- ▶ Refer to the Musculoskeletal System table at the back of the book for related tests by body system.

Computed Tomography, Cardiac Scoring

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), heart vessel calcium CT, helical/spiral CT, cardiac plaque CT.

AREA OF APPLICATION: Heart.

CONTRAST: None.

DESCRIPTION: Cardiac scoring is a noninvasive test for quantifying coronary artery calcium content. Coronary artery disease (CAD) occurs when the arteries that carry blood and oxygen to the heart muscle become clogged or built up with plaque. Plaque buildup slows the flow of blood to the heart muscle, causing ischemia and increasing the risk of heart failure. The procedure begins with a computed tomography (CT) scan of the heart. The patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion by detecting and recording differences in plaque density after having an x-ray beam passed through the tissues. The scanner takes an image of the beating heart while the patient holds his or her breathe for approximately 20 sec. The procedure requires no contrast medium injections. These density measurements are sent to a computer that produces a digital analysis of the anatomy, enabling the health care provider (HCP) to

look at the quantified amount of calcium (cardiac plaque score) in the coronary arteries. The data can be recorded on photographic or x-ray film or stored in digital format as digitized computer data.

INDICATIONS:

- Detect and quantify coronary artery calcium content
CAD is the leading cause of death in most industrialized nations
Cardiac scoring is a more powerful predictor of CAD than cholesterol screening
Of all myocardial infarctions (MIs), 45% occur in people younger than age 65
Of women who have had MIs, 44% will die within 1 yr after the attack
Women are more likely to die of heart disease than of breast cancer
- Family history of heart disease
- Screening for coronary artery calcium in patients with:
Diabetes
High blood pressure
High cholesterol
High-stress lifestyle
Overweight by 20% or more
Personal history of smoking
Sedentary lifestyle
- Screening for coronary artery plaque in patients with chest pain of unknown cause

RESULT:**Normal findings in:**

- If the score is 100 or less, the probability of having significant CAD is minimal or is unlikely to be causing a narrowing at the time of the examination.

Abnormal findings in:

- If the score is between 101 and 400, a significant amount of calcified plaque was found in the coronary arteries. There is an increased risk of a future MI, and a medical assessment of cardiac risk factors needs to be done. Additional testing may be needed.
- If the score is greater than 400, the procedure has detected extensive calcified plaque in the coronary arteries, which may have caused a critical narrowing of the vessels. A full medical assessment is needed as soon as possible. Further testing may be needed, and treatment may be needed to reduce the risk of MI.

CRITICAL VALUES: N/A

INTERFERING FACTORS:**This procedure is contraindicated for:**

- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Retained barium or radiological contrast from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ

visualization and cause unclear images

- Improper adjustment of the radiographic equipment to accommodate obese or thin patients, which can cause overexposure or underexposure and a poor-quality study
- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Consultation with the HCP should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses the coronary arteries.

- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of patient's coronary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support

- before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, or sedatives.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium, if given.
- ▶ The patient should not fast or restrict fluids prior to the procedure. Protocols may vary from facility to facility.
- ▶ Instruct the patient to remove all external metallic objects from the area to be examined.

INTRATEST:

- ▶ Ensure the patient has complied with pretesting preparations.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast medium, emergency drugs, and sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative

to a child or to an uncooperative adult, as ordered.

- ◆ Place the patient in the supine position on an exam table.
- ◆ A rapid series of images is taken of the vessels to be examined.
- ◆ Instruct the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ◆ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ◆ The needle is removed, and a pressure dressing is applied over the puncture site.
- ◆ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ◆ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ◆ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ◆ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.

- ◆ Instruct the patient to apply cold compresses to the insertion site as needed, to reduce discomfort or edema.
- ◆ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ◆ Inform the patient that diarrhea may occur after ingestion of oral contrast media.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, atrial natriuretic peptide, BNP, BUN, calcium, chest x-ray, cholesterol (total, HDL, LDL), CRP, coronary angiography, CT thorax, CK and isoenzymes, creatinine echocardiography, echocardiography transesophageal ECG, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, lung scan, magnesium, MRI chest, MI scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, triglycerides, and troponin.
- ◆ Refer to the Cardiovascular System table at the back of the book for related tests by body system.

Computed Tomography, Colonoscopy

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), CT virtual colonoscopy, CT colonography.

AREA OF APPLICATION: Colon.

CONTRAST: Screening examinations are done without IV iodinated contrast medium. Examinations done to clarify questionable or abnormal areas may require IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) colonoscopy is a non-invasive technique that involves examining the colon by taking multiple CT scans of the patient's colon and rectum and using computer software to create three-dimensional images. The procedure is used to detect polyps, which are growths of tissue in the colon or rectum. Some types of polyps increase the risk of colon cancer, especially if they are large or if a patient has several polyps. Compared to conventional colonoscopy, CT colonoscopy is less effective in detecting polyps smaller than 5 mm, more effective when the polyps are between 5 and 9.9 mm, and most effective when the polyps are 10 mm or larger. This test may be valuable for patients who have diseases rendering them unable to undergo conventional colonoscopy (e.g., bleeding disorders, lung or heart disease) and for patients who are unable to undergo the sedation required for traditional colonoscopy. The procedure is less invasive than conventional colonoscopy, with little risk of complications and no recovery time. CT colonoscopy can be done as an outpatient procedure,

and the patient may return to work or usual activities the same day.

CT colonoscopy and conventional colonoscopy require the bowel to be cleansed before the examination. The patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion by detecting and recording differences in densities in the colon after having an x-ray beam passed through it. The screening procedure requires no contrast medium injections, but if a suspicious area or abnormality is detected, a repeat series of images may be completed after IV contrast medium is given. These density measurements are sent to a computer that produces a digital analysis of the anatomy, enabling a health care provider (HCP) to look at slices or thin sections of certain anatomic views of the colon and vascular system. The data can be recorded on photographic or x-ray film or stored in digital format as digitized computer data.

A drawback of CT colonoscopy is that polyp removal and biopsies of tissue in the colon must be done using conventional colonoscopy. Therefore, if polyps are discovered during CT colonoscopy and biopsy becomes necessary, the patient must undergo bowel preparation a second time.

INDICATIONS:

- Detect polyps in the colon
- Evaluate the colon for metachronous lesions
- Evaluate the colon in patients with obstructing rectosigmoid disease
- Evaluate polyposis syndromes
- Evaluate the site of resection for local recurrence of lesions
- Examine the colon in patients with heart or lung disease, patients unable to be sedated, and patients unable to undergo colonoscopy
- Failure to visualize the entire colon during conventional colonoscopy
- Identify metastases
- Investigate cause of positive occult blood test
- Investigate further after an abnormal barium enema
- Investigate further when flexible sigmoidoscopy is positive for polyps

RESULT:

Normal findings in:

- Normal colon and rectum, with no evidence of polyps or growths

Abnormal findings in:




- Abnormal endoluminal wall of the colon
- Extraluminal extension of primary cancer
- Mesenteric and retroperitoneal lymphadenopathy
- Metachronous lesions
- Metastases of cancer

- Polyps or growths in colon or rectum
- Tumor recurrence after surgery

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium, if contrast is used.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure, if contrast is used.
-  Patients who are in renal failure, if contrast is used.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment

- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure may include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with the HCP should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the colon.
- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine,

seafood, anesthetics, or contrast mediums.

- ▶ Obtain a history of the patient's gastrointestinal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a radiology department, usually by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a

transient headache after injection of contrast medium.

- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 6 to 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluids, and medication restrictions and pretesting preparations; assure that food and fluids have been restricted for at least 6 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast (if used), emergency drugs, and sedatives.
- ▶ Administer an anti-anxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.

- ▶ Place the patient in the supine position on an exam table.
- ▶ The colon is distended with room air or carbon dioxide by means of a rectal tube and balloon retention device. Maximal colonic distention is guided by patient tolerance.
- ▶ If IV contrast is used, a rapid series of images is taken during and after injection.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ The sequence of images is repeated in the prone position.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.

- ◆ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ◆ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ◆ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ◆ Inform the patient that diarrhea may occur after ingestion of oral contrast media.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.

- Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include barium enema, BUN, cancer antigens (CA 19–9), CEA, colonoscopy, CT abdomen, creatinine, fecal analysis, KUB studies, MRI abdomen, PET pelvis, proctosigmoidoscopy, and US pelvis.
- ◆ Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Computed Tomography, Pancreas

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT, abdominal CT, helical/spiral CT).

AREA OF APPLICATION: Pancreas.

CONTRAST: With or without oral or IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) is a noninvasive procedure used to enhance certain anatomic views of the abdominal structures. It becomes an invasive procedure when contrast medium is used. CT of the pancreas aids in the diagnosis or evaluation of pancreatic cysts, pseudocysts, inflammation, tumors, masses, metastases, abscesses, and trauma. In all but the thinnest or most emaciated patients, the pancreas is surrounded by fat that clearly defines its margins. During

the procedure the patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion. Differences in tissue density are detected and recorded, and are viewable as computerized digital images. Slices or thin sections of certain anatomic views of the

kidneys and associated vascular system are reviewed to allow differentiation of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas and aneurysms. The procedure is repeated after intravenous injection of iodinated contrast medium for vascular evaluation or after oral ingestion of contrast medium for evaluation of bowel and adjacent structures. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning produces a series of moving images of the scanned area. The CT scan can be used to guide biopsy needles into areas of pancreatic masses to obtain tissue for laboratory analysis and for placement of needles to aspirate cysts or abscesses. CT scanning can monitor mass, cyst, or tumor growth and post-therapy response.

INDICATIONS:

- Detect dilation or obstruction of the pancreatic ducts
- Differentiate between pancreatic disorders and disorders of the retroperitoneum
- Evaluate benign or cancerous tumors or metastasis to the pancreas
- Evaluate pancreatic abnormalities (e.g., bleeding, pancreatitis, pseudocyst, abscesses)
- Evaluate unexplained weight loss, jaundice, and epigastric pain
- Monitor and evaluate effectiveness of medical or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and contour of the pancreas, which lies obliquely in the upper abdomen




Abnormal findings in:

- Acute or chronic pancreatitis
- Obstruction of the pancreatic ducts
- Pancreatic abscesses
- Pancreatic carcinoma
- Pancreatic pseudocyst
- Pancreatic tumor

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the abdomen and pancreatic area.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or

sensitivities to latex, iodine, seafood, anesthetics or other contrast medium.

- ▶ Obtain a history of the patient's GI, hepatobiliary, and genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually contrast medium and normal saline are infused.
- ▶ Inform the patient that he or she may experience nausea, a feeling of

warmth, a salty or metallic taste, or a transient headache after injection of contrast medium.

- ▶ The patient should fast and restrict fluids for 2 to 4 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ The patient may be requested to drink approximately 450 mL of a dilute barium solution (approximately 1% barium) beginning 1 hr before the examination. This is administered to distinguish GI organs from the other abdominal organs.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluids, and medication restrictions and pretesting preparations; assure that food and fluids have been restricted for at least 2 to 4 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast medium, emergency drugs, and sedatives.

- ▶ Administer an anti-anxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast medium is used, a rapid series of images is taken during and after injection.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.

- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amylase, angiography of the abdomen, biopsy intestinal, BUN, CA 125, CA 19-9, creatinine, ERCP, lipase, MRI abdomen, and US pancreas.
- ▶ Refer to the Gastrointestinal, Hepatobiliary, and Genitourinary System tables at the back of the book for related tests by body system.

C

Computed Tomography, Pelvis

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), pelvic CT, helical/spiral CT.

AREA OF APPLICATION: Pelvis.

CONTRAST: With or without oral or IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) of the pelvis is a noninvasive procedure used to enhance certain anatomic views of the pelvic structures. It becomes an invasive procedure when intravenous contrast medium is used. During the procedure the patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in

a three-dimensional fashion. Differences in tissue density are detected and recorded, and are viewable as computerized digital images. Slices or thin sections of certain anatomic views of the pelvic structures and associated vascular system are reviewed to allow differentiation of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas and aneurysms. The procedure is repeated after intravenous injection of iodinated contrast medium for vascular evaluation or after oral ingestion of contrast

medium for evaluation of bowel and adjacent structures. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning produces a series of moving images of the scanned area. The CT scan can be used to guide biopsy needles into areas of pelvic masses to obtain tissue for laboratory analysis and for placement of needles to aspirate cysts or abscesses. CT scanning can monitor mass, cyst, or tumor growth and post-therapy response.

INDICATIONS:

- Assist in differentiating between benign and malignant tumors
- Detect tumor extension of masses and metastasis into the pelvic area
- Differentiate infectious from inflammatory processes
- Evaluate pelvic lymph nodes
- Evaluate cysts, masses, abscesses, ureteral and bladder calculi, gastrointestinal (GI) bleeding and obstruction, and trauma
- Monitor and evaluate effectiveness of medical, radiation, or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and shape of pelvic organs and vascular system

Abnormal findings in:

- Bladder calculi
- Ectopic pregnancy
- Fibroid tumors
- Hydrosalpinx
- Ovarian cyst or abscess
- Primary and metastatic neoplasms




CRITICAL VALUES:

- Ectopic pregnancy
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the GI tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and can produce unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the pelvis and pelvic organs.
- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's GI, reproductive, and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually contrast medium and normal saline are infused.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium.

- ▶ The patient should fast and restrict fluids for 2 to 4 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ The patient may be requested to drink approximately 450 mL of a dilute barium solution (approximately 1% barium) beginning 1 hr before the examination. This is administered to distinguish GI organs from the other abdominal organs.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluids, and medication restrictions and pretesting preparations; assure that food and fluids have been restricted for at least 2 to 4 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast, emergency drugs, and sedatives.
- ▶ Administer an anti-anxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a

child or to an uncooperative adult, as ordered.

- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast medium is used, a rapid series of images is taken during and after injection.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the insertion site as needed, to reduce discomfort or edema.

- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography pelvis, barium enema, BUN, calculus kidney stone panel, carcinoembryonic and cancer antigens, creatinine, HCG, IVP, KUB film, MRI abdomen, proctosigmoidoscopy, UA, and US pelvis.
- ▶ Refer to the Gastrointestinal, Reproductive, and Genitourinary System tables at the back of the book for related tests by body system.

Computed Tomography, Pituitary

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), pituitary CT, helical/spiral CT.

AREA OF APPLICATION: Pituitary/brain.

CONTRAST: With or without IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) of the pituitary is a noninvasive procedure that enhances certain anatomic views of the pituitary gland and perisellar region. It becomes invasive when a contrast medium is used. This procedure aids in the evaluation of pituitary adenoma, craniopharyngioma, meningioma, aneurysm, metastatic disease, exophthalmos, and cysts. Visualization of bony septa in the sphenoid sinus and evaluation for nonpneumatization of

the sphenoid sinus are best performed with this procedure. During the procedure the patient lies on a table and moves in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion. Differences in tissue density are detected and recorded, and are viewable as

computerized digital images. Slices or thin sections of certain anatomic views of the pituitary and associated vascular system are reviewed to allow differentiations of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas and aneurysms. The procedure may be repeated after iodinated contrast medium is given IV for blood vessel and vascular evaluation. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning produces a series of moving images of the scanned area. Tumors, before and after therapy, may be monitored by CT scanning.

INDICATIONS:

- Assist in differentiating between benign and malignant tumors
- Detect aneurysms and vascular abnormalities
- Detect congenital anomalies, such as partially empty sella
- Detect tumor extension of masses and metastasis
- Determine pituitary size and location in relation to surrounding structures
- Evaluate cysts, masses, abscesses, and trauma
- Monitor and evaluate effectiveness of medical, radiation, or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and shape of the pituitary fossa, cavernous sinuses, and vascular system

Abnormal findings in:




- Abscess
- Adenoma
- Aneurysm

- Chordoma
- Craniopharyngioma
- Cyst
- Meningioma
- Metastasis
- Pituitary hemorrhage

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Retained contrast from a previous radiological procedure
- Metallic objects (e.g., jewelry, dentures, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure may include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the brain and pituitary gland.
- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually contrast medium and normal saline are infused.
- ▶ Inform the patient that he or she may experience nausea, a feeling of

warmth, a salty or metallic taste, or a transient headache after injection of contrast medium.

- ▶ Instruct the patient to remove dentures and other metallic objects from the area to be examined.
- ▶ There are no food or fluid restrictions unless by medical direction. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with medication restrictions and pretesting preparations.
- ▶ Ensure the patient has removed dentures and all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast medium, emergency drugs, and sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast medium is used, a rapid series of images is taken during and after injection.

- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast medium is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the insertion site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.
- ▶ Recognize anxiety related to test results. Discuss the implications

of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH and challenge tests, BUN, CT angiography, CT brain, cortisol and challenge tests, creatinine, PET brain, MRA, and MRI brain.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Computed Tomography, Renal

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), kidney CT, helical/spiral CT.

AREA OF APPLICATION: Kidney.

CONTRAST: With or without oral or IV iodinated contrast medium.

DESCRIPTION: Renal computed tomography (CT) is a noninvasive procedure used to enhance certain anatomic views of the renal structures. It becomes an invasive procedure when contrast medium is used. CT scanning is a safe, rapid method for renal evaluation that is independent of renal function. It provides unique cross-sectional anatomic information and is unsurpassed in evaluating lesions containing fat or calcium. During the procedure the patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray

beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion. Differences in tissue density are detected and recorded, and are viewable as computerized digital images. Slices or thin sections of certain anatomic views of the kidneys and associated vascular system are reviewed to allow differentiation of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas and aneurysms. The procedure is repeated after IV injection of iodinated contrast medium for vascular evaluation or after oral ingestion of contrast medium for

evaluation of bowel and adjacent structures. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning produces a series of moving images of the area scanned. The CT scan can be used to guide biopsy needles into areas of suspected tumors to obtain tissue for laboratory analysis and to guide placement of catheters for drainage of renal abscesses. Tumors, before and after therapy, may be monitored with CT scanning.

INDICATIONS:

- Aid in the diagnosis of congenital anomalies, such as polycystic kidney disease, horseshoe kidney, absence of one kidney, or kidney displacement
- Aid in the diagnosis of perirenal hematomas and abscesses and assist in localizing for drainage
- Assist in differentiating between benign and malignant tumors
- Assist in differentiating between an infectious and an inflammatory process
- Detect aneurysms and vascular abnormalities
- Detect bleeding or hyperplasia of the adrenal glands
- Detect tumor extension of masses and metastasis into the renal area
- Determine kidney size and location in relation to the bladder in post-transplant patients
- Determine presence and type of adrenal tumor, such as benign adenoma, cancer, or pheochromocytoma
- Evaluate abnormal fluid accumulation around the kidney
- Evaluate cysts, masses, abscesses, renal calculi, obstruction, and trauma

- Evaluate spread of a tumor or invasion of nearby retroperitoneal organs
- Monitor and evaluate effectiveness of medical, radiation, or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and shape of kidneys and vascular system


Abnormal findings in:



- Adrenal tumor or hyperplasia
- Congenital anomalies, such as polycystic kidney disease, horseshoe kidney, absence of one kidney, or kidney displacement
- Dilation of the common hepatic duct, common bile duct, or gallbladder
- Renal artery aneurysm
- Renal calculi and ureteral obstruction
- Renal cell carcinoma
- Renal cysts or abscesses
- Renal laceration, fracture, tumor, and trauma
- Perirenal abscesses and hematomas
- Primary and metastatic neoplasms

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.

-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the kidney.
- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ▶ Obtain a history of the patient's GI and genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.

- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually contrast medium and normal saline are infused.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ The patient may be requested to drink approximately 450 mL of a dilute barium solution (approximately 1% barium) beginning 1 hr before the examination. This is administered to distinguish GI organs from the other abdominal organs.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 2 to 4 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast, emergency drugs, and sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast is used, a rapid series of images is taken during and after injection.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:**INTRATEST:**

- ▶ Ensure the patient has complied with dietary, fluids, and medication restrictions for 2 to 4 hr prior to the procedure.
- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity,

as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.

- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the insertion site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, angiography adrenal, renal biopsy, BUN, calculus/kidney stone panel, catecholamines, creatinine, CT abdomen, homovanillic acid, IVP, KUB, MRI abdomen, US renal, and VMA.
- ▶ Refer to the Gastrointestinal and Genitourinary System tables at the back of the book for related tests by body system.

Computed Tomography, Spine

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), spine CT, CT myelogram.

AREA OF APPLICATION: Spine.

CONTRAST: With or without oral or IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) of the spine is a noninvasive procedure that enhances certain anatomic views of the spinal structures. CT scanning is more versatile than conventional radiography and

can easily detect and identify tumors and their types. During the procedure the patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated elec-

tronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion. Differences in tissue density are detected and recorded, and are viewable as computerized digital images. Slices or thin sections of certain anatomic views of the spine and associated vascular system are reviewed to allow differentiations of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas and aneurysms. The procedure may be repeated after intravenous injection of iodinated contrast medium for vascular evaluation. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning produces a series of moving images of the scanned area. CT scanning can be used to guide biopsy needles into areas of suspected tumor to obtain tissue for laboratory analysis and to guide placement of catheters for drainage of abscesses. Tumor size, progression, and pre- and post-therapy changes may be monitored with CT scanning.

INDICATIONS:

- Assist in differentiating between benign and malignant tumors
- Detect congenital spinal anomalies, such as spina bifida, meningocele, and myelocoele
- Detect herniated intervertebral disks
- Detect paraspinal cysts
- Detect vascular malformations
- Monitor and evaluate effectiveness of medical, radiation, or surgical therapies

RESULT:

Normal findings in:

- Normal density, size, position, and shape of spinal structures

Abnormal findings in:

- Congenital spinal malformations, such as meningocele, myelocoele, or spina bifida
- Herniated intervertebral disks
- Paraspinal cysts
- Spinal tumors
- Spondylosis (cervical or lumbar)
- Vascular malformations




CRITICAL VALUES:

- Cord compression
- Fracture
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye.
The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure may include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a HCP should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the spine and spinal canal.
- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs and nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important

in providing psychological support before, during, and after the procedure.

- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually contrast medium and normal saline are infused.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food or fluid restrictions unless by medical direction. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions and pretesting preparations
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ If ordered, establish an IV fluid line for the injection of contrast medium, emergency drugs, and sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.

- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast medium is used, a rapid series of images is taken during and after injection.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the insertion site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.

- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be needed

to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ALP, BUN, creatinine, MRI bone, bone scan, radiography of the bones.
- ◆ Refer to the Musculoskeletal System table at the back of the book for related tests by body system.

Computed Tomography, Spleen

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), splenic CT, helical/spiral CT.

AREA OF APPLICATION: Abdomen/spleen.

CONTRAST: With or without oral or IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) of the spleen is a noninvasive procedure that enhances certain anatomic views of the splenic structures. It becomes an invasive procedure with the use of contrast medium. The spleen is not often the organ of interest when abdominal CT scans are obtained. However, a wide variety of splenic variations and abnormalities may be detected on abdominal scans designed to evaluate the liver, pancreas, or retroperitoneum. During the procedure the patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion. Differences in tissue density are

detected and recorded, and are viewable as computerized digital images. Slices or thin sections of certain anatomic views of the spleen and associated vascular system are reviewed to allow differentiation of solid, cystic, inflammatory, or vascular lesions, as well as identification of suspected hematomas and aneurysms. The procedure is repeated after IV injection of iodinated contrast medium for vascular evaluation or after oral ingestion of contrast medium for evaluation of bowel and adjacent structures. Images can be recorded on photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning produces a series of moving images of the scanned area. The CT scan can be used to guide biopsy needles into areas of splenic masses to obtain tissue for laboratory analysis and for

placement of needles to aspirate cysts or abscesses. CT scanning can monitor mass, cyst, or tumor growth and post-therapy response.

INDICATIONS:

- Assist in differentiating between benign and malignant tumors
- Detect tumor extension of masses and metastasis
- Differentiate infectious from inflammatory processes
- Evaluate cysts, masses, abscesses, and trauma
- Evaluate the presence of an accessory spleen, polysplenia, or asplenia
- Evaluate splenic vein thrombosis
- Monitor and evaluate effectiveness of medical, radiation, or surgical therapies

RESULT:

Normal findings in:

- Normal size, position, and shape of the spleen and associated vascular system

Abnormal findings in:

- Abdominal aortic aneurysm
- Hematomas
- Hemoperitoneum
- Primary and metastatic neoplasms
- Splenic cysts or abscesses
- Splenic laceration, tumor, infiltration, and trauma


CRITICAL VALUES:

- Abscess
- Hemorrhage
- Laceration



Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye.

The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.

- Patients who are claustrophobic.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the abdomen and spleen.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's GI, hepatobiliary and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that

barium studies were performed more than 4 days before the CT scan.

- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually contrast medium and normal saline are infused.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ The patient may be requested to drink approximately 450 mL of a dilute barium solution (approximately 1% barium) beginning 1 hr before the examination. This is administered to distinguish GI organs from the other abdominal organs.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 2 to 4 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from

facility to facility.

- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluids, and medication restrictions for 2 to 4 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast medium, emergency drugs, and sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast medium is used, a rapid series of images is taken during and after injection.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast medium is used.
- ▶ The needle is removed, and a pressure

dressing is applied over the puncture site.

- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this

procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography abdomen, BUN, creatinine, KUB film, MRI abdomen, and US liver.
- ▶ Refer to the Gastrointestinal, Hepatobiliary, and Genitourinary System tables at the back of the book for related tests by body system.

Computed Tomography, Thoracic

SYNONYM/ACRONYM: Computed axial tomography (CAT), computed transaxial tomography (CTT), chest CT, helical/spiral CT.

AREA OF APPLICATION: Thorax.

CONTRAST: With or without oral or IV iodinated contrast medium.

DESCRIPTION: Computed tomography (CT) of the thorax is more detailed than a chest x-ray. It is a noninvasive procedure used to enhance certain anatomic views of the lungs, heart, and mediastinal structures. It becomes invasive when a contrast medium is used. During the procedure, the patient lies on a table and is moved in and out of a doughnut-like device called a *gantry*, which houses the x-ray tube and associated electronics. The scanner uses multiple x-ray beams and a series of detectors that rotate around the patient to produce cross-sectional views in a three-dimensional fashion. Differences in tissue density are detected and recorded, and are viewable as computerized digital images. Slices or thin sections of certain anatomic views of the spine, spinal cord, and lung areas are reviewed to allow differentiations of solid, cystic, inflammatory, or vascular lesions. Images can be recorded on

photographic or x-ray film or stored in digital format as digitized computer data. Cine scanning is used to produce moving images of the heart.

INDICATIONS:

- Detect aortic aneurysms
- Detect bronchial abnormalities, such as stenosis, dilation, or tumor
- Detect lymphomas, especially Hodgkin's disease
- Detect mediastinal and hilar lymphadenopathy
- Detect primary and metastatic pulmonary, esophageal, or mediastinal tumors
- Detect tumor extension of neck mass to thoracic area
- Determine blood, fluid, or fat accumulation in tissues, pleuritic space, or vessels
- Differentiate aortic aneurysms from tumors near the aorta
- Differentiate between benign and malignant tumors
- Differentiate infectious from inflammatory processes

- Differentiate tumor from tuberculosis
- Evaluate cardiac chambers and pulmonary vessels
- Evaluate the presence of plaque in cardiac vessels
- Monitor and evaluate effectiveness of medical or surgical therapeutic regimen
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.

RESULT:**Normal findings in:**

- Normal size, position, and shape of thoracic organs, tissues, and structures

Abnormal findings in:



- Aortic aneurysm
- Chest, mediastinal, spine, or rib lesions
- Cysts or abscesses
- Enlarged lymph nodes
- Esophageal pathology, including tumors
- Hodgkin's disease
- Pleural effusion
- Pneumonitis
- Pneumothorax
- Pulmonary embolism

CRITICAL VALUES:

- Aortic aneurysm
- Aortic dissection
- Pneumothorax
- Pulmonary embolism

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:**This procedure is contraindicated for:**

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are claustrophobic.
- Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Patients with extreme claustrophobia unless sedation is given before the study
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure may include hemorrhage, infection at the IV needle insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.

- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the scanning room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the chest.
- ▶ Obtain a history of the patient's complaints or clinical symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's respiratory system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure results of coagulation testing are obtained and recorded prior to the procedure; BUN and creatinine results are also needed if contrast medium is to be used.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before the CT scan.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin

(Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.

- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient the procedure is usually performed in a radiology suite by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually contrast medium and normal saline are infused.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Inform the patient that he or she may experience nausea, a feeling of warmth, a salty or metallic taste, or a transient headache after injection of contrast medium.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 2 to 4 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluid, and medication restrictions for 2 to 4 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the

procedure. Use nonionic contrast medium for the procedure.

- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of contrast medium, emergency drugs, and sedatives.
- ▶ Administer an anti-anxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If IV contrast medium is used, a rapid series of images is taken during and after injection.
- ▶ Ask the patient to inhale deeply and hold his or her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure. Monitor and administer an antiemetic agent if ordered. Ready an emesis basin for use.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm) if contrast is used.
- ▶ The needle is removed, and a pressure dressing is applied over the puncture site.
- ▶ *Observe the needle insertion site for bleeding, inflammation, or hematoma formation.*

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every

2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.

- ▶ If contrast was used, observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ If contrast was used, advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the insertion site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to increase fluid intake to help eliminate the contrast medium, if used.
- ▶ Inform the patient that diarrhea may occur after ingestion of oral contrast medium.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, BUN, chest x-ray, complete blood count, creatinine, echocardiogram, gallium scan, lung scan, MRI chest, mediastinoscopy, and pleural fluid analysis.
- ▶ Refer to the Respiratory System table at the back of the book for related tests by body system.

Coombs' Antiglobulin, Direct

SYNONYM/ACRONYM: Direct antiglobulin testing (DAT).

SPECIMEN: Serum (1 mL) collected in a red-top tube and whole blood (1 mL) collected in lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Agglutination) Negative (no agglutination).

DESCRIPTION: Direct antiglobulin testing (DAT) detects in-vivo antibody sensitization of red blood cells (RBCs). Immunoglobulin G (IgG) produced in certain disease states or in response to certain drugs can coat the surface of RBCs, resulting in cellular damage and hemolysis. When DAT is performed, RBCs are taken from the patient's blood sample, washed with saline to remove residual globulins, and mixed with anti-human globulin reagent. If the anti-human globulin reagent causes agglutination of the patient's RBCs, specific antiglobulin reagents can be used to determine whether the patient's RBCs are coated with IgG, complement, or both. (See monograph titled "Blood Groups and Antibodies," and Appendix D for more information regarding transfusion reactions.)

INDICATIONS:

- Detect autoimmune hemolytic anemia or hemolytic disease of the newborn
- Evaluate suspected drug-induced hemolytic anemia
- Evaluate transfusion reaction

RESULT:

Positive findings in:

- **Antibodies formed during these circumstances or conditions**

attach to the patient's RBCs and hemolysis occurs.

- Anemia (**Autoimmune hemolytic, drug-induced**)
- Hemolytic disease of the newborn
- Infectious mononucleosis
- Lymphomas
- *Mycoplasma* pneumonia
- Paroxysmal cold hemoglobinuria (**Idiopathic or disease-related**)
- Passively acquired antibodies from plasma products
- Post-cardiac vascular surgery
- Systemic lupus erythematosus and other connective tissue immune disorders
- Transfusion reactions (**Blood incompatibility**)

Negative findings in:

- Samples in which sensitization of erythrocytes has not occurred

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may cause a positive DAT include acetaminophen, aminopyrine, aminosalicilic acid, ampicillin, antihistamines, aztreonam, cephalosporins, chlorinated hydrocarbon insecticides, chlorpromazine, chlorpropamide, cisplatin, clonidine, dipyron, ethosuximide, fenfluramine, hydralazine, hydrochlorothiazide, ibuprofen, insulin, isoniazid, levodopa, mefenamic acid, melphalan, methadone, methicillin, methyl dopa, moxalactam, penicillin, phenytoin, probenecid,

procainamide, quinidine, quinine, rifampin, stibophen, streptomycin, sulfonamides, and tetracycline.

- Wharton's jelly may cause a false-positive DAT.
- Cold agglutinins and large amounts of paraproteins in the specimen may cause false-positive results.
- Newborns' cells may give negative results in ABO hemolytic disease.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to detect associated conditions or drug therapies that can result in cell hemolysis.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture. If a cord sample is to be taken from a newborn, inform parents that the sample will be obtained at the time of delivery and will not result in blood loss to the infant.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. Cord specimens are obtained by inserting a needle attached to a syringe into the umbilical vein. The specimen is drawn into the syringe and gently expressed into the appropriate collection container.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Note positive test results in cord blood of neonate; also assess newborn's bilirubin and hematocrit levels. Results may indicate the need for immediate exchange transfusion of fresh whole blood that has been typed and cross-matched with the mother's serum.
- ▶ Inform the postpartum patient of the implications of positive test results in cord blood. Prepare the newborn for exchange transfusion, on medical direction.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include bilirubin, blood groups and antibodies, Coombs' indirect antiglobulin (IAT), complete blood count, hematocrit, complete

blood count, hemoglobin, Ham's test, haptoglobin.

- Refer to the Hematopoietic System table at the end of the book for related tests by body system.

Coombs' Antiglobulin, Indirect

C

SYNONYM/ACRONYM: Indirect antiglobulin test (IAT), antibody screen.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Agglutination) Negative (no agglutination).

DESCRIPTION: The indirect antiglobulin test (IAT) detects and identifies unexpected circulating complement molecules or antibodies in the patient's serum. The first use of this test was for the detection and identification of anti-D using an indirect method. The test is now commonly used to screen a patient's serum for the presence of antibodies that may react against transfused red blood cells (RBCs). During testing, the patient's serum is allowed to incubate with reagent RBCs. The reagent RBCs used are from group O donors and have most of the clinically significant antigens present (D, C, E c, e, K, M, N, S, s, Fy^a, Fy^b, Jk^a, and Jk^b). Antibodies present in the patient's serum coat antigenic sites on the RBC membrane. The reagent cells are washed with saline to remove any unbound antibody. Antihuman globulin is added in the final step of the test. If the patient's serum contains antibodies, the antihuman globulin will cause the antibody-coated RBCs to stick together or agglutinate. (See monograph titled "Blood Groups and Antibodies," and Appendix D for more information regarding transfusion reactions.)

INDICATIONS:

- Detect other antibodies in maternal blood that can be potentially harmful to the fetus
- Determine antibody titers in Rh-negative women sensitized by an Rh-positive fetus
- Screen for antibodies before blood transfusions
- Test for the weak Rh-variant antigen D^u.

RESULT:**Positive findings in:**

- **Circulating antibodies or medications attach to the patient's RBCs and hemolysis occurs.**
- Hemolytic anemia (**Drug-induced or autoimmune**)
- Hemolytic disease of the newborn
- Incompatible crossmatch
- Maternal-fetal Rh incompatibility

Negative findings in:

- Samples in which the patient's antibodies exhibit dosage effects (i.e., stronger reaction with homozygous than with heterozygous expression of an antigen) and reagent erythrocyte antigens contain single-dose expressions of the corresponding antigen (heterozygous)

- Samples in which reagent erythrocyte antigens are unable to detect low-prevalence antibodies
- Samples in which sensitization of erythrocytes has not occurred (complete absence of antibodies)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may cause a positive IAT include penicillin, phenacetin, quinidine, and rifampin.
- Recent administration of dextran, whole blood or fractions, or IV contrast media can result in a false-positive reaction.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to check donor and recipient blood cells for antibodies prior to blood transfusion.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Inform pregnant women that negative tests during the first 12 wk of gestation should be repeated at 28 wk to rule out the presence of an antibody.
- ▶ Positive test results in pregnant women after 28 wk of gestation indicate the need for antibody identification testing.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include bilirubin, blood groups and antibodies, Coombs' direct antiglobulin (DAT), haptoglobin, complete blood count, hematocrit, and complete blood count, hemoglobin.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Copper

SYNONYM/ACRONYM: Cu.

SPECIMEN: Serum (1 mL) collected in a royal blue-top, trace element-free tube.

REFERENCE VALUE: (Method: Atomic absorption spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 0.157)
Newborn–5 d	9–46 mcg/dL	1.4–7.2 micromol/L
1–5 yr	80–150 mcg/dL	12.6–23.6 micromol/L
6–9 yr	84–136 mcg/dL	13.2–21.4 micromol/L
10–14 yr	80–121 mcg/dL	12.6–19.0 micromol/L
15–19 yr	80–171 mcg/dL	10.1–18.4 micromol/L
Adult		
Men	70–140 mcg/dL	11.0–22.0 micromol/L
Women	80–155 mcg/dL	12.6–24.3 micromol/L
Pregnant women	118–302 mcg/dL	18.5–47.4 micromol/L

Values for African Americans are 8% to 12% higher.

DESCRIPTION: Copper is an important cofactor for the enzymes that participate in the formation of hemoglobin and collagen. Copper is also a component of coagulation factor V and assists in the oxidation of glucose. It is required for melanin pigment formation and maintenance of myelin sheaths and is used to synthesize ceruloplasmin. Copper levels vary with intake. Levels vary diurnally and peak during morning hours. This mineral is absorbed in the stomach and duodenum, stored in the liver, and excreted in urine and in feces with bile salts. Copper deficiency results in neutropenia and a hypochromic, microcytic anemia that is not responsive to iron therapy. Other signs and symptoms of copper deficiency include osteoporosis,

depigmentation of skin and hair, impaired immune system response, and possible neurologic and cardiac abnormalities.

INDICATIONS:

- Assist in establishing a diagnosis of Menkes disease
- Assist in establishing a diagnosis of Wilson's disease
- Monitor patients receiving long-term parenteral nutrition therapy

RESULT:

Increased in:

Ceruloplasmin is an acute phase reactant protein and the main protein binder of copper; therefore copper levels will be increased in many inflammatory conditions including cancer.

- Anemias (**Response to increased RBC production**)
- Ankylosing rheumatoid spondylitis
- Biliary cirrhosis (**Release from damaged liver tissue**)
- Collagen diseases
- Complications of renal dialysis
- Hodgkin's disease
- Infections
- Inflammation
- Leukemia
- Malignant neoplasms
- Myocardial infarction (**Toxicity can cause heart problems**)
- Pellagra
- Poisoning from copper-contaminated solutions or insecticides
- Pregnancy (**Estrogen increases copper levels**)
- Pulmonary tuberculosis
- Rheumatic fever
- Rheumatoid arthritis
- Systemic lupus erythematosus
- Thalassemias
- Thyroid disease (hypothyroid or hyperthyroid)
- Trauma
- Typhoid fever
- Use of copper intrauterine device
- Malabsorption disorders (celiac disease, tropical sprue) (**Inadequate absorption**)
- Malnutrition (**Inadequate intake**)
- Menkes disease (**Severe X-linked defect causing failed transport to the liver and tissues**)
- Nephrotic syndrome (**Loss of transport proteins**)
- Occipital horn syndrome (OHS) (**Inherited disorder of copper metabolism; similar to Menkes**)
- Wilson's disease (**Genetic defect causing failed transport to the liver and tissues**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase copper levels include anticonvulsants and oral contraceptives.
- Drugs that may decrease copper levels include citrates, penicillamine, and valproic acid.
- Excessive therapeutic intake of zinc may interfere with intestinal absorption of copper.

Decreased in:

- Burns (**Related to loss of stores in tissue and possibly to competitive inhibition of zinc containing medications or vitamins administered as part of burn therapy**)
- Cystic fibrosis
- Dysproteinemia (**Affects transport to and from stores**)
- Infants (**especially premature infants**) receiving milk deficient in copper
- Iron-deficiency anemias (some) (**Copper promotes absorption of iron from the intestines and transfer from tissues to plasma; it is essential to hemoglobin formation**)
- Long-term total parenteral nutrition (**Inadequate intake**)

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to monitor exposure to copper.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic, hepatobiliary, and immune systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Nutritional considerations:** Instruct the patient with increased copper levels to avoid foods rich in copper and to increase intake of elements (zinc, iron, calcium, and manganese) that interfere with copper absorption, as appropriate. Copper deficiency does not normally occur in adults, but patients receiving long-term total parenteral nutrition should be evaluated if signs and symptoms of copper deficiency appear. These patients should be informed that organ meats, shellfish, nuts, and legumes are good sources of dietary copper.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include biopsy liver, ceruloplasmin, complete blood count, and zinc.
- Refer to the Hematopoietic, Hepatobiliary, and Immune System tables at the end of the book for related tests by body system.

Cortisol and Challenge Tests

SYNONYM/ACRONYM: Hydrocortisone, compound F.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable. Care must be taken to use the same type of collection container if serial measurements are to be taken.

Procedure	Medication Administered	Recommended Collection Times
ACTH stimulation, rapid test	1 mcg (low-dose protocol) cosyntropin IM	3 cortisol levels: baseline immediately before bolus, 30 min after bolus, and 60 min after bolus
CRH stimulation	IV dose of 1 mcg/kg ovine CRH at 9 a.m. or 8 p.m.	8 cortisol and 8 ACTH levels: baseline collected 15 min before injection, 0 minutes before injection, and then 5, 15, 30, 60, 120, and 180 min after injection
Dexamethasone suppression (overnight)	Oral dose of 1 mg dexamethasone (Decadron) at 11 p.m.	Collect cortisol at 8 a.m. on the morning after the dexamethasone dose
Metyrapone stimulation (overnight)	Oral dose of 30 mg/kg metyrapone with snack at midnight	Collect cortisol and ACTH at 8 a.m. on the morning after the metyrapone dose

ACTH = adrenocorticotropic hormone; CRH = corticotropin-releasing hormone; IM = intramuscular; IV = intravenous.

REFERENCE VALUE: (Method: Immunoassay)

	Conventional Units	SI Units
<i>Cortisol</i>		
		<i>(Conventional Units × 27.6)</i>
8 a.m.	5–25 mcg/dL	138–690 nmol/L
4 p.m.	3–16 mcg/dL	83–442 nmol/L
<i>ACTH Challenge Tests</i>		
CRH stimulation	2–4 fold increase over baseline ACTH or cortisol level	2–4 fold increase over baseline value
<i>Dexamethasone Suppressed</i>		
		<i>(Conventional Units × 27.6)</i>
	Cortisol less than 3 mcg/dL next day	Less than 83 nmol/L
<i>ACTH (Cosyntropin) Stimulated, Rapid Test</i>		
		<i>(Conventional Units × 27.6)</i>
	Cortisol greater than 20 mcg/dL	Greater than 552 nmol/L
<i>Metyrapone Stimulated</i>		
		<i>(Conventional Units × 0.22)</i>
	ACTH greater than 75 pg/mL	Greater than 16.5 pmol/L
		<i>(Conventional Units × 27.6)</i>
	Cortisol less than 3 mcg/dL next day	Less than 83 nmol/L

ACTH = adrenocorticotropic hormone; CRH = corticotropin-releasing hormone.

DESCRIPTION: Cortisol (hydrocortisone) is the predominant glucocorticoid secreted in response to

stimulation by the hypothalamus and pituitary adrenocorticotropic hormone (ACTH). Cortisol

stimulates gluconeogenesis, mobilizes fats and proteins, antagonizes insulin, and suppresses inflammation. Measuring levels of cortisol in blood is the best indicator of adrenal function. Cortisol secretion varies diurnally, with highest levels occurring on awakening and lowest levels occurring late in the day. Bursts of cortisol excretion can occur at night. Cortisol and ACTH test results are evaluated together because they each control the other's concentrations (i.e., any change in one causes a change in the other). ACTH levels exhibit a diurnal variation, peaking between 6 and 8 a.m. and reaching the lowest point between 6 and 11 p.m. Evening levels are generally one-half to two-thirds lower than morning levels. (See monograph titled "Adrenocorticotropic Hormone [and Challenge Tests].")

INDICATIONS:

- Detect adrenal hyperfunction (Cushing's syndrome)
- Detect adrenal hypofunction (Addison's disease)

RESULT: *The dexamethasone suppression test is useful in differentiating the causes for increased cortisol levels. Dexamethasone is a synthetic steroid that suppresses secretion of ACTH. With this test, a baseline morning cortisol level is collected, and the patient is given a 1-mg dose of dexamethasone at bedtime. A second specimen is collected the following morning. If cortisol levels have not been suppressed, adrenal adenoma may be suspected. The dexamethasone suppression test also produces abnormal results in patients with psychiatric illnesses.*

The corticotropin-releasing hormone (CRH) stimulation test works as well as the dexamethasone suppression test in distinguishing Cushing's disease from conditions in which ACTH is secreted ectopically. In this test, cortisol levels are measured after an injection of CRH. A fourfold increase in cortisol levels above baseline is seen in Cushing's disease. No increase in cortisol is seen if ectopic ACTH secretion is the cause.

The ACTH (cosyntropin) stimulated, rapid test is used when adrenal insufficiency is suspected. Cosyntropin is a synthetic form of ACTH. A baseline cortisol level is collected before the injection of cosyntropin. Specimens are subsequently collected at 30- and 60-min intervals. If the adrenal glands are functioning normally, cortisol levels rise significantly after administration of cosyntropin.

The metyrapone stimulation test is used to distinguish corticotropin-dependent (pituitary Cushing's disease and ectopic Cushing's disease) from corticotropin-independent (carcinoma of the lung or thyroid) causes of increased cortisol levels. Metyrapone inhibits the conversion of 11-deoxycortisol to cortisol. Cortisol levels should decrease to less than 3 mcg/dL if normal pituitary stimulation by ACTH occurs after an oral dose of metyrapone. Specimen collection and administration of the medication are performed as with the overnight dexamethasone test.

Increased in:

Conditions that result in excessive production of cortisol

- Adrenal adenoma
- Cushing's syndrome
- Ectopic ACTH production
- Hyperglycemia
- Pregnancy
- Stress

Decreased in:**Conditions that result in adrenal hypofunction and corresponding low levels of cortisol.**

- Addison's disease
- Adrenogenital syndrome
- Hypopituitarism

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs and substances that may increase cortisol levels include amphetamines, anticonvulsants, clomipramine, corticotropin, cortisone, CRH, cyclic AMP, ether, fenfluramine, hydrocortisone, insulin, lithium, methadone, metoclopramide, naloxone, opiates, oral contraceptives, prednisolone, ranitidine, spironolactone, tetracosactrin, and vasopressin.
- Drugs and substances that may decrease cortisol levels include barbiturates, beclomethasone, betamethasone, clonidine, danazol, desoximetasone, desoxycorticosterone, dexamethasone, ephedrine, etomidate, flucinolone, ketoconazole, levodopa, lithium, methylprednisolone, metyrapone, midazolam, morphine, nitrous oxide, oxazepam, phenytoin, ranitidine, and trimipramine.
- Test results are affected by the time this test is done because cortisol levels vary diurnally.
- Stress and excessive physical activity can produce elevated levels.
- Normal values can be obtained in the presence of partial pituitary deficiency.
- Recent radioactive scans within 1 wk of the test can interfere with test results.
- ◆ The metyrapone stimulation test is contraindicated in patients with suspected adrenal insufficiency.
- ◆ Metyrapone may cause gastrointestinal distress and/or

confusion. Administer oral dose of metyrapone with milk and snack.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to assist in the diagnosis of adrenocortical insufficiency.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's endocrine system, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that multiple specimens may be required. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions unless by medical direction.
- ◆ Drugs that enhance steroid metabolism may be withheld by medical direction prior to metyrapone stimulation testing.
- ◆ Instruct the patient to minimize stress to avoid raising cortisol levels.

INTRATEST:

- ◆ Have emergency equipment readily available.
- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Collect specimen between 6 and 8 a.m., when cortisol levels are highest. Perform a venipuncture.
- ◆ Adverse reactions to metyrapone include nausea and vomiting (N/V), abdominal pain, headache, dizziness, sedation, allergic rash, decreased white blood cell count, or bone marrow depression. Signs and symptoms of overdose or acute adrenocortical insufficiency include cardiac arrhythmias, hypotension, dehydration, anxiety, confusion, weakness, impairment of consciousness, N/V, epigastric pain, diarrhea, hyponatremia, and hyperkalemia.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the Cushing's Support and Research Foundation (www.csrff.net).
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ACTH and challenge tests, angiography adrenal, chloride, CT abdomen, CT pituitary, DHEA, glucagon, glucose, glucose tolerance test, growth hormone, insulin, MRI abdomen, MRI pituitary, renin, sodium, and testosterone.
- ◆ Refer to the Endocrine System table at the back of the book for related tests by body system.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual medications, as directed by the HCP.

C-Peptide

SYNONYM/ACRONYM: Connecting peptide insulin, insulin C-peptide, proinsulin C-peptide.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Immunochemiluminometric assay, ICMA)

Conventional Units	SI Units (Conventional Units × 0.333)
0.78–1.8 ng/mL	0.26–0.63 nmol/L

DESCRIPTION: C-peptide is a biologically inactive peptide formed when beta cells of the pancreas convert proinsulin to insulin. Most of C-peptide is secreted by the kidneys. C-peptide levels usually correlate with insulin levels and provide a reliable indication of how well the beta cells secrete insulin. Release of C-peptide is not affected by exogenous insulin administration. C-peptide values double after stimulation with glucose or glucagon. An insulin/C-peptide ratio less than 1.0 indicates endogenous insulin secretion, whereas a ratio of greater than 1.0 indicates an excess of exogenous insulin.

INDICATIONS:

- Assist in the diagnosis of insulinoma: Serum levels of insulin and C-peptide are elevated.
- Detect suspected factitious cause of hypoglycemia (excessive insulin administration): an increase in blood insulin from injection does not increase C-peptide levels.
- Determine beta cell function when insulin antibodies preclude accurate measurement of serum insulin production.
- Distinguish between insulin-dependent (type 1) and non-insulin-dependent (type 2) diabetes (with C-peptide-stimulating test): Patients with diabetes whose C-peptide stimulation level is greater than 18 ng/mL can be managed without insulin treatment.
- Evaluate hypoglycemia.

RESULT:

Increased in:

- Islet cell tumor (**Excessive endogenous insulin production**)
- Non-insulin-dependent (type 2) diabetes (**Related to increased insulin production**)

- Pancreas or beta cell transplants (**Related to increased insulin production**)
- Renal failure (**Increase in circulating levels of C-peptide related to decreased excretion**)

Decreased in:

- Factitious hypoglycemia (**Pancreas does not produce insulin in response to increased blood insulin levels from insulin injection**)
- Insulin-dependent (type 1) diabetes (**Pancreas is not producing insulin**)
- Pancreatectomy (**Pancreas is absent**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase C-peptide levels include betamethasone, chloroquine, danazol, deferoxamine, ethinyl estradiol, oral contraceptives, prednisone, and rifampin.
- Drugs that may decrease C-peptide levels include atenolol and calcitonin.
- C-peptide and endogenous insulin levels do not always correlate in obese patients.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used in the evaluation of hypoglycemia.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ The patient should fast for at least 10 hr before specimen collection. Protocols may vary from facility to facility.
- ▶ There are no fluid or medication restrictions unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions and pretesting preparations; assure that food has been restricted for at least 10 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet as directed by the HCP.
- ▶ **Nutritional considerations:** Abnormal C-peptide levels may be associated with diabetes. Instruct the diabetic patient, as appropriate, in nutritional management of the disease. Patients who adhere to dietary recommendations report a better

general feeling of health, better weight management, greater control of glucose and lipid values, and improved use of insulin. There is no “diabetic diet”; however, there are many meal-planning approaches with nutritional goals endorsed by the American Dietetic Association. The nutritional requirements of each diabetic patient need to be determined individually with the appropriate health care professionals, particularly health care workers trained in nutrition.

- ▶ Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy). Emphasize, as appropriate, that good control of glucose levels delays the onset and slows the progression of diabetic retinopathy, nephropathy, and neuropathy.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient’s lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Diabetes Association (www.diabetes.org).
- ▶ Reinforce information given by the patient’s HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient’s symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CT cardiac scoring, cortisol, creatinine, creatinine clearance, EMG, ENG, fluorescein angiography, fructose, fundus photography, glucagon, glucose, glucose tolerance tests, glycated hemoglobin, insulin, insulin antibodies, microalbumin, plethysmography, and visual fields test.
- ▶ Refer to the Endocrine System table at the end of the book for related tests by body system.

C-Reactive Protein

SYNONYM/ACRONYM: CRP.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: High-sensitivity immunoassay, nephelometry)

High-sensitivity immunoassay (cardiac applications) 1.0–3.0 mg/L

Nephelometry	Conventional Units
Adult	0–4.9 mg/L

DESCRIPTION: C-reactive protein (CRP) is a glycoprotein produced by the liver in response to acute inflammation. The CRP assay is a nonspecific test that determines the presence (not the cause) of inflammation; it is often ordered in conjunction with erythrocyte sedimentation rate (ESR). CRP assay is a more sensitive and rapid indicator of the presence of an inflammatory process than ESR. CRP disappears from the serum rapidly when inflammation has subsided. The inflammatory process and its association with atherosclerosis make the presence of CRP, as detected by highly sensitive CRP assays, a potential marker for coronary artery disease. It is believed that the inflammatory process may instigate the conversion of a stable plaque to a weaker one that can rupture and occlude an artery.

INDICATIONS:

- Assist in the differential diagnosis of appendicitis and acute pelvic inflammatory disease
- Assist in the differential diagnosis of Crohn's disease and ulcerative colitis
- Assist in the differential diagnosis of rheumatoid arthritis and uncomplicated systemic lupus erythematosus (SLE)
- Assist in the evaluation of coronary artery disease
- Detect the presence or exacerbation of inflammatory processes
- Monitor response to therapy for autoimmune disorders such as rheumatoid arthritis

RESULT:

Increased in:

Conditions associated with an inflammatory response stimulate production of CRP.

- Acute bacterial infections
- Crohn's disease
- Inflammatory bowel disease
- Myocardial infarction

(Inflammation of the coronary vessels is associated with increased CRP levels and increased risk for coronary vessel injury which may result in distal vessel plaque occlusions.)

- Pregnancy (second half)
- Rheumatic fever
- Rheumatoid arthritis
- SLE
- Syndrome X (metabolic syndrome) (**Inflammation of the coronary vessels is associated with increased CRP levels and increased risk for coronary vessel injury which may result in distal vessel plaque occlusions.**)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may decrease CRP levels include aurothiomalate, methotrexate, NSAIDs, oral contraceptives (progestogen effect), penicillamine, pentopril, and sulfasalazine.
- NSAIDs, salicylates, and steroids may cause false-negative results because of suppression of inflammation.
- Falsely elevated levels may occur with the presence of an intrauterine device.
- Lipemic samples that are turbid in appearance may be rejected for analysis when nephelometry is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to indicate nonspecific inflammatory response; the highly sensitive CRP is used to assess risk for cardiovascular and peripheral vascular disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities

to latex. The patient may complain of pain related to the inflammatory process in connective or other tissues.

- ▶ Obtain a history of the patient's cardiovascular and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include antiarrhythmic drugs, ANA, antibodies, anticyclic citrullinated apolipoprotein A and B, AST, arthroscopy, ANP, blood gases, BMD, bone scan, BNP, calcium (blood and

ionized), cholesterol (total, HDL, and LDL), CRP, complete blood count, CT, cardiac scoring, CK and isoenzymes, echocardiography, ESR, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, MRI chest, MRI musculoskeletal, MI scan, myocardial perfusion scan, myoglobin, PET heart, potassium, radiography bone, RF, synovial fluid analysis, triglycerides, troponin, and complete blood count, WBC count and differential. Refer to the Cardiovascular and Immune System tables at the end of the book for related tests by body system.

Creatine Kinase and Isoenzymes

SYNONYM/ACRONYM: CK and isoenzymes.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Serial specimens are highly recommended. Care must be taken to use the same type of collection container if serial measurements are to be taken.

REFERENCE VALUE: (Method: Enzymatic for CK, electrophoresis for isoenzymes; enzyme immunoassay techniques are in common use for CK-MB)

	Conventional & SI Units
Total CK	
<i>Newborn to 1 yr</i>	2 × adult values
<i>Male (children and adult)</i>	50–204 units/L
<i>Female (children and adult)</i>	36–160 units/L
CK isoenzymes by electrophoresis	
CK-BB	Absent
CK-MB	Less than 4–6%
CK-MM	94–96%
CK-MB by immunoassay	0–3 ng/mL
CK-MB Index	0–2.5

CK = creatine kinase; CK-BB = CK isoenzyme in brain; CK-MB = CK isoenzyme in heart; CK-MM = CK isoenzyme in skeletal muscle. The CK-MB Index is the CK-MB (by immunoassay) divided by the total CK, and then multiplied by 100. For example a CK-MB by immunoassay of 25 ng/mL with a total CK of 230 units/L would have a CK-MB index of 10.9.

DESCRIPTION: Creatine kinase (CK) is an enzyme that exists almost exclusively in skeletal muscle, heart muscle, and, in smaller amounts, in the brain and lungs. This enzyme is important in intracellular storage and energy release. Three isoenzymes, based on primary location, have been identified by electrophoresis: brain and lungs CK-BB, cardiac CK-MB, and skeletal muscle CK-MM. When injury to these tissues occurs, the enzymes are released into the bloodstream. Levels increase and decrease in a predictable time frame. Measuring the serum levels can help determine the extent and timing of the damage. Noting the presence of the specific isoenzyme helps determine the location of the tissue damage. Atypical forms of CK can be identified. Macro-CK, an immunoglobulin complex of normal CK isoenzymes, has no clinical significance. Mitochondrial-CK is sometimes identified in the sera of seriously ill patients, especially those with metastatic carcinoma.

Acute myocardial infarction (MI) releases CK into the serum within the first 48 hr; values return to normal in about 3 days.

The isoenzyme CK-MB appears in the first 4 to 6 hr, peaks in 24 hr, and usually returns to normal in 72 hr. Recurrent elevation of CK suggests reinfarction or extension of ischemic damage. Significant elevations of CK are expected in early phases of muscular dystrophy, even before the clinical signs and symptoms appear. CK elevation diminishes as the disease progresses and muscle mass decreases. Differences in total CK with age and gender relate to the fact that the predominant isoenzyme is muscular in origin. Body builders have higher values, whereas older individuals have lower values because of deterioration of muscle mass.

Serial use of the mass assay for CK-MB with serial cardiac troponin I, myoglobin, and serial electrocardiograms in the assessment of MI has largely replaced the use of CK isoenzyme assay by electrophoresis. CK-MB mass assays are more sensitive and rapid than electrophoresis. Studies have demonstrated a high positive predictive value for acute MI when the CK-MB (by immunoassay) is greater than 10 ng/mL with a relative CK-MB index greater than 3.0.

Timing for Appearance and Resolution of Serum/Plasma Cardiac Markers in Acute MI

<i>Cardiac Marker</i>	<i>Appearance (hr)</i>	<i>Peak (hr)</i>	<i>Resolution (Days)</i>
AST	6–8	24–48	3–4
CK (Total)	4–6	24	2–3
CK-MB	4–6	15–20	2–3
LDH	12	24–48	10–14
Myoglobin	1–3	4–12	1
Troponin I	2–6	15–20	5–7

INDICATIONS:

- Assist in the diagnosis of acute MI and evaluate cardiac ischemia (CK-MB)
- Detect musculoskeletal disorders that do not have a neurological basis, such as dermatomyositis or Duchenne's muscular dystrophy (CK-MM)
- Determine the success of coronary artery reperfusion after streptokinase infusion or percutaneous transluminal angioplasty, as evidenced by a decrease in CK-MB

RESULT:**Increased in:**

CK is released from any damaged cell in which it is stored so conditions that affect the brain, heart, or skeletal muscle and cause cellular destruction demonstrate elevated CK levels and correlating isoenzyme source CK-BB, CK-MB, CK-MM.

- Alcoholism (CK-MM)
- Brain infarction (extensive) (CK-BB)
- Congestive heart failure (CK-MB)
- Delirium tremens (CK-MM)
- Dermatomyositis (CK-MM)
- Head injury (CK-BB)
- Hypothyroidism (CK-MM related to metabolic effect on skeletal muscle tissue)
- Hypoxic shock (CK-MM related to muscle damage from lack of oxygen)
- Gastrointestinal (GI) tract infarction (CK-MM)
- Loss of blood supply to any muscle (CK-MM)
- Malignant hyperthermia (CK-MM related to skeletal muscle injury)
- MI (CK-MB)
- Muscular dystrophies (CK-MM)
- Myocarditis (CK-MB)
- Neoplasms of the prostate, bladder, and GI tract (CK-MM)
- Polymyositis (CK-MM)
- Pregnancy; during labor (CK-MM)

- Prolonged hypothermia (CK-MM)
- Pulmonary edema (CK-MM)
- Pulmonary embolism (CK-MM)
- Reye's syndrome (CK-BB)
- Rhabdomyolysis (CK-MM)
- Surgery (CK-MM)
- Tachycardia (CK-MB)
- Tetanus (CK-MM related to muscle injury from injection)
- Trauma (CK-MM)

Decreased in:

- Small stature (Related to lower muscle mass than average stature)
- Sedentary lifestyle (Related to decreased muscle mass)

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase total CK levels include any intramuscularly injected preparations because of tissue trauma caused by injection.
- Drugs that may decrease total CK levels include dantrolene and statins.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is primarily used to assist in monitoring MI and some disorders of the musculoskeletal system.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's cardiovascular and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs,

nutritional supplements, and nutraceuticals.

- Review the procedure with the patient. Inform the patient that a series of samples will be required. (Samples at time of admission and 2 to 4 hr, 6 to 8 hr, and 12 hr after admission are the minimal recommendations. Protocols may vary from facility to facility. Additional samples may be requested.) Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- Remove the needle, and apply a pressure dressing over the puncture site.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Nutritional considerations:** Increased CK levels may be associated with coronary artery disease (CAD). Nutritional therapy is recommended for individuals identified to be at high risk for developing CAD. If overweight, the patient should be encouraged to achieve a normal weight. The American Heart Association Step 1 and Step 2 diets may be helpful in

achieving a goal of lowering total cholesterol and triglyceride levels. The Step 1 diet emphasizes a reduction in foods high in saturated fats and cholesterol. Red meats, eggs, and dairy products are the major sources of saturated fats and cholesterol. If triglycerides are also elevated, the patient should be advised to eliminate or reduce alcohol and simple carbohydrates from the diet. The Step 2 diet recommends stricter reductions.

- Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Heart Association (www.americanheart.org).
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, ANP, blood gases, BNP, calcium (blood and ionized), cholesterol (total, HDL and LDL), CRP, CT cardiac scoring, echocardiography, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI chest, MI scan, myocardial perfusion scan, myoglobin, pericardial fluid, PET heart, potassium, triglycerides, and troponin.
- Refer to the Cardiovascular and Musculoskeletal System tables at the end of the book for related tests by body system.

Creatinine, Blood

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 88.4)
1–5 yr	0.3–0.5 mg/dL	27–44 micromol/L
6–10 yr	0.5–0.8 mg/dL	44–71 micromol/L
Adult male	0.6–1.2 mg/dL	53–106 micromol/L
Adult female	0.5–1.1 mg/dL	44–97 micromol/L

National Kidney Foundation recommends the use of 2 decimal places in reporting serum creatinine for use in calculating eGFR.

DESCRIPTION: Creatinine is the end product of creatine metabolism. Creatine resides almost exclusively in skeletal muscle, where it participates in energy-requiring metabolic reactions. In these processes, a small amount of creatine is irreversibly converted to creatinine, which then circulates to the kidneys and is excreted. The amount of creatinine generated in an individual is proportional to the mass of skeletal muscle present and remains fairly constant, unless there is massive muscle damage resulting from crushing injury or degenerative muscle disease. Creatinine values also decrease with age owing to diminishing muscle mass. Blood urea nitrogen (BUN) is often ordered with creatinine for comparison. The BUN/creatinine ratio is also a useful indicator of disease. The ratio should be between 10:1 and 20:1. Creatinine is the ideal

substance for determining renal clearance because a fairly constant quantity is produced within the body. The creatinine clearance test measures a blood sample and a urine sample to determine the rate at which the kidneys are clearing creatinine from the blood; this reflects the glomerular filtration rate (see monograph titled “Creatinine, Urine, and Creatinine Clearance, Urine”).

Chronic kidney disease (CKD) is a significant health concern worldwide. An international effort to standardize methods to identify and monitor CKD has been undertaken by the National Kidney Disease Education Program (NKDEP), the International Confederation of Clinical Chemistry and Laboratory Medicine, and the European Communities Confederation of Clinical Chemistry. International efforts

have resulted in development of an Isotope Dilution Mass Spectrometry (IDMS) reference method for standardized measurement of creatinine. The National Kidney Foundation (NKF) has recommended use of an equation to estimate glomerular filtration rate (eGFR). The equation is based on factors identified in the NKF Modification of Diet in Renal Disease (MDRD) study. The equation includes four factors: serum or plasma creatinine value, age (in years), gender, and race. The equation is valid only for patients between the ages of 18 and 70. A correction factor is incorporated in the equation if the patient is African American as CKD is more prevalent in African Americans; results are approximately 20% higher. It is very important to know whether the creatinine has been measured using an IDMS traceable test method because the values will differ; results are lower. The equations have not been validated for pregnant women, patients younger than 18 or older than 70, patients with serious comorbidities, or patients with extremes in body size, muscle mass, or nutritional status. eGFR calculators can be found at the National Kidney Disease Education Program (www.nkdep.nih.gov/professionals/gfr_calculators/index.htm).

The equation used for creatinine methods that are NOT traceable to IDMS reference method is:

- If creatinine is reported in mg/L

$$[\text{eGFR (mL/min/1.73 m}^2) = 186 \times (\text{creat})^{-1.154} \times (\text{Age})^{0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})]$$

- If creatinine is reported in (SI) micromol/L

$$[\text{eGFR (mL/min/1.73 m}^2) = 186 \times (\text{creat}/88.4)^{-1.154} \times (\text{Age})^{0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})]$$

The equation used for creatinine methods that ARE traceable to IDMS reference method is:

- If creatinine is reported in mg/dL

$$[\text{eGFR (mL/min/1.73 m}^2) = 175 \times (\text{creat})^{-1.154} \times (\text{Age})^{0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})]$$

- If creatinine is reported in (SI) micromol/L

$$[\text{eGFR (mL/min/1.73 m}^2) = 175 \times (\text{creat}/88.4)^{-1.154} \times (\text{Age})^{0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})]$$

INDICATIONS:

- Assess a known or suspected disorder involving muscles in the absence of renal disease
- Evaluate known or suspected impairment of renal function

RESULT:

Increased in:

- Acromegaly (**Related to increased muscle mass**)
- Congestive heart failure (**Related to decreased renal blood flow**)
- Dehydration (**Hemoconcentration**)
- Gigantism (**Related to increased muscle mass**)
- Poliomyelitis (**Increased release from damaged muscle**)
- Renal calculi (**Related to decreased renal excretion due to obstruction**)
- Renal disease, acute and chronic renal failure (**Related to decreased urinary excretion**)

- Rhabdomyolysis (**Increased release from damaged muscle**)
- Shock (**Increased release from damaged muscle**)

Decreased in:

- Decreased muscle mass **owing to debilitating disease or increasing age**
- Hyperthyroidism (**Related to increased GFR**)
- Inadequate protein intake (**Related to decreased muscle mass**)
- Liver disease (severe) (**Related to fluid retention**)
- Muscular dystrophy (**Related to decreased muscle mass**)
- Pregnancy
- Small stature (**Related to decreased muscle mass**)

CRITICAL VALUES:

Potential critical value is greater than 7.4 mg/dL (nondialysis patient).

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms. Chronic renal insufficiency is identified by creatinine levels between 1.5 and 3.0 mg/dL; chronic renal failure is present at levels greater than 3.0 mg/dL.

Possible interventions may include renal or peritoneal dialysis and organ transplant, but early discovery of the cause of elevated creatinine levels might avoid such drastic interventions.

INTERFERING FACTORS:

- Drugs and substances that may increase creatinine levels include acebutolol, acetaminophen (overdose), acetylsalicylic acid, aldatense, amikacin, amiodarone, amphotericin B, arginine, arsenicals, ascorbic acid, asparaginase, barbiturates, capreomycin, captopril, carbutamide, carvedilol, cephalothin, chlorthalidone, cimetidine, cisplatin, clofibrate,

colistin, corn oil (Lipomul), cyclosporine, dextran, doxycycline, enalapril, ethylene glycol, gentamicin, indomethacin, ipodate, kanamycin, levodopa, mannitol, methicillin, methoxyflurane, mitomycin, neomycin, netilmycin, nitrofurantoin, NSAIDs, oxyphenbutazone, paromomycin, penicillin, pentamidine, phosphorus, plicamycin, radiographic agents, semustine, streptokinase, streptozocin, tetracycline, thiazides, tobramycin, triamterene, vancomycin, vasopressin, viomycin, and vitamin D.

- Drugs that may decrease creatinine levels include citrates, dopamine, ibuprofen, and lisinopril.
- High blood levels of bilirubin and glucose can cause false decreases in creatinine.
- A diet high in meat can cause increased creatinine levels.
- Ketosis can cause a significant increase in creatinine.
- Hemolyzed specimens are unsuitable for analysis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess kidney function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs,

nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.
- ▶ Instruct the patient to refrain from excessive exercise for 8 hr before the test.

INTRATEST:

- ▶ Ensure that the patient has complied with activity restrictions; assure that activity has been restricted for at least 8 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle, and apply a pressure dressing over the puncture site.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual activity as directed by the HCP.
- ▶ **Nutritional considerations:** Increased creatinine levels may be associated with kidney disease. The nutritional needs of patients with kidney disease vary

widely and are in constant flux. Anorexia, nausea, and vomiting commonly occur, prompting the need for continuous nutritional monitoring for malnutrition, especially among patients receiving long-term hemodialysis therapy.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the National Kidney Foundation (www.kidney.org) or the National Kidney Disease Education Program (www.nkdep.nih.gov).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include anion gap, antibiotic drugs, ANF, BNP, biopsy muscle, blood gases, BUN, calcium, calculus kidney stone panel, CT abdomen, CT renal, CK and isoenzymes, creatinine clearance, cystoscopy, echocardiography, echocardiography transesophageal, electrolytes, EMG, ENG, glucagon, glucose, glycolated hemoglobin, insulin, IVP, KUB studies, lung perfusion scan, microalbumin, osmolality, phosphorus, renogram, retrograde ureteropyelography, TSH, thyroxine, uric acid, and UA.
- ▶ Refer to the Genitourinary and Musculoskeletal System tables at the end of the book for related tests by body system.

Creatinine, Urine, and Creatinine Clearance, Urine

SYNONYM/ACRONYM: N/A

SPECIMEN: Urine (5 mL) from an unpreserved random or timed specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units
<i>Urine Creatinine (Conventional Units \times 8.84)</i>		
2–3 yr	6–22 mg/kg/24 hr	53–194 micromol/kg/24 hr
4–18 yr	12–30 mg/kg/24 hr	106–265 micromol/kg/24 hr
Adult male	14–26 mg/kg/24 hr	124–230 micromol/kg/24 hr
Adult female	11–20 mg/kg/24 hr	97–177 micromol/kg/24 hr
<i>Creatinine Clearance (Conventional Units \times 0.0167)</i>		
Children	70–140 mL/min/1.73 m ²	1.17–2.33 mL/s/1.73 m ²
Adult male	85–125 mL/min/1.73 m ²	1.42–2.08 mL/s/1.73 m ²
Adult female	75–115 mL/min/1.73 m ²	1.25–1.92 mL/s/1.73 m ²
For each decade after 40 yr	Decrease of 6–7 mL/min/1.73 m ²	Decrease of 0.06–0.07 mL/s/1.73 m ²

DESCRIPTION: Creatinine is the end product of creatine metabolism. Creatine resides almost exclusively in skeletal muscle, where it participates in energy-requiring metabolic reactions. In these processes, a small amount of creatine is irreversibly converted to creatinine, which then circulates to the kidneys and is excreted. The amount of creatinine generated in an individual is proportional to the mass of skeletal muscle present and remains fairly constant, unless there is massive muscle damage resulting from crushing injury or degenerative muscle disease. Creatinine values decrease with advancing age owing to diminishing muscle mass. Although the measurement of urine

creatinine is an effective indicator of renal function, the creatinine clearance test is more precise. The creatinine clearance test measures a blood sample and a urine sample to determine the rate at which the kidneys are clearing creatinine from the blood; this reflects the glomerular filtration rate and is based on an estimate of body surface.

Chronic kidney disease (CKD) is a significant health concern worldwide. An international effort to standardize methods to identify and monitor CKD has been undertaken by the National Kidney Disease Education Program (NKDEP), the International Confederation of Clinical Chemistry and Laboratory Medicine, and the European

Communities Confederation of Clinical Chemistry. International efforts have resulted in development of an Isotope Dilution Mass Spectrometry (IDMS) reference method for standardized measurement of creatinine. The National Kidney Foundation (NKF) has recommended use of an equation to estimate glomerular filtration rate (eGFR). The equation is based on factors identified in the NKF Modification of Diet in Renal Disease (MDRD) study. The equation includes four factors: serum or plasma creatinine value, age in years, gender, and race. The equation is valid only for patients between the ages of 18 and 70. A correction factor is incorporated in the equation if the patient is African American as CKD is more prevalent in African Americans; results are approximately 20% higher. It is very important to know whether the creatinine has been measured using an IDMS traceable test method because the values will differ; results are lower. The equations have not been validated for pregnant women, patients younger than 18 or older than 70, patients with serious comorbidities, or patients with extremes in body size, muscle mass, or nutritional status. eGFR calculators can be found at the NKDEP (www.nkdep.nih.gov/professionals/gfr_calculators/index.htm).

The equation used for creatinine methods that are *NOT* traceable to IDMS reference method is:

- If creatinine is reported in mg/dL

$$[\text{eGFR (mL/min/1.73 m}^2\text{)} = 186 \times (\text{creat})^{-1.154} \times (\text{Age})^{0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})]$$

- If creatinine is reported in (SI) micromol/L

$$[\text{eGFR (mL/min/1.73 m}^2\text{)} = 186 \times (\text{creat}/88.4)^{-1.154} \times (\text{Age})^{0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})]$$

The equation used for creatinine methods that *ARE* traceable to IDMS reference method is:

- If creatinine is reported in mg/dL

$$[\text{eGFR (mL/min/1.73 m}^2\text{)} = 175 \times (\text{creat})^{-1.154} \times (\text{Age})^{0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})]$$

- If creatinine is reported in (SI) micromol/L

$$[\text{eGFR (mL/min/1.73 m}^2\text{)} = 175 \times (\text{creat}/88.4)^{-1.154} \times (\text{Age})^{0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African American})]$$

INDICATIONS:

- Determine the extent of nephron damage in known renal disease (at least 50% of functioning nephrons must be lost before values are decreased)
- Determine renal function before administering nephrotoxic drugs
- Evaluate accuracy of a 24-hr urine collection, based on the constant level of creatinine excretion
- Evaluate glomerular function
- Monitor effectiveness of treatment in renal disease

RESULT:

Increased in:

- Acromegaly (*related to increased muscle mass*)
- Carnivorous diets (*increased intake of creatine, which is metabolized to creatinine and excreted by the kidneys*)
- Exercise (*related to muscle damage; increased renal blood flow*)

- Gigantism (*related to increased muscle mass*)

Decreased in:

Conditions that decrease GFR, impair kidney function, or reduce renal blood flow will decrease renal excretion of creatinine

- Acute or chronic glomerulonephritis
- Chronic bilateral pyelonephritis
- Leukemia
- Muscle wasting diseases (*related to abnormal creatinine production; decreased production reflected in decreased excretion*)
- Paralysis (*related to abnormal creatinine production; decreased production reflected in decreased excretion*)
- Polycystic kidney disease
- Shock
- Urinary tract obstruction (e.g., from calculi)
- Vegetarian diets (*diets that exclude intake of animal muscle, the creatine source metabolized to creatinine and excreted by the kidneys*)

CRITICAL VALUES:

- Degree of impairment:
Borderline: 62.5–80 mL/min/1.73 m²
Slight: 52–62.5 mL/min/1.73 m²
Mild: 42–52 mL/min/1.73 m²
Moderate: 28–42 mL/min/1.73 m²
Marked: Less than 28 mL/min/1.73 m²
Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms.

INTERFERING FACTORS:

- Drugs that may increase urine creatinine levels include ascorbic acid, cefoxitin, cephalothin, corticosteroids, fluoxymesterone, levodopa, methandrosthenolone, methotrexate, methyl dopa, nitrofurans (including nitrofurazone), oxymetholone, phenolphthalein, and prednisone.

- Drugs that may increase urine creatinine clearance include enalapril, oral contraceptives, prednisone, and ramipril.
- Drugs that may decrease urine creatinine levels include anabolic steroids, androgens, captopril, and thiazides.
- Drugs that may decrease the urine creatinine clearance include acetylsalicylic acid, amphotericin B, carbenoxolone, chlorthalidone, cimetidine, cisplatin, cyclosporine, guanidine, ibuprofen, indomethacin, mitomycin, oxyphenbutazone, paromycin, probenecid (coadministered with digoxin), and thiazides.
- Excessive ketones in urine may cause falsely decreased values.
- Failure to follow proper technique in collecting 24-hr specimen may invalidate test results.
- Failure to refrigerate specimen throughout urine collection period allows decomposition of creatinine, causing falsely decreased values.
- Consumption of large amounts of meat, excessive exercise, and stress should be avoided for 24 hr before the test. Protocols may vary from facility to facility.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assess renal function.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's genitourinary system, symptoms,

and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain to the patient that there should be no discomfort during the urine collection procedure. Inform the patient that a blood sample for creatinine will be required on the day urine collection begins or at some point during the 24 hr collection period. (see monograph titled "Creatinine, Blood" for additional information).
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ There are no fluid or medication restrictions unless by medical direction.
- ▶ Instruct the patient to refrain from eating meat during the test. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and activity restrictions for 24 hr prior to the procedure; assure that ingestion of meat has been restricted during the test.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Random specimen (Collect in Early Morning) Clean-Catch Specimen:

- ▶ Instruct the male patient to
 - (1) thoroughly wash his hands,
 - (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to
 - (1) thoroughly wash her hands;
 - (2) cleanse the labia from front to back;
 - (3) while keeping the labia separated, void a small amount into the toilet; and
 - (4) without interrupting the urine stream, void directly into the specimen container.

Pediatric Urine Collector:

- ▶ Put on gloves. Appropriately cleanse the genital area and allow the area to dry. Remove the covering over the adhesive strips on the collector bag and apply over the genital area. Diaper the child. When specimen is obtained, place the entire collection bag in a sterile urine container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Urinary Catheterization:

- ▶ Place female patient in lithotomy position or male patient in supine position. Using sterile technique, open the straight urinary catheterization kit and perform urinary catheterization. Place the retained urine in a sterile specimen container.

Suprapubic Aspiration:

- ▶ Place the patient in a supine position. Cleanse the area with antiseptic and drape with sterile drapes. A needle is inserted through the skin into the bladder. A syringe attached to the needle is used to aspirate the urine sample. The

needle is then removed and a sterile dressing is applied to the site. Place the sterile sample in a sterile specimen container.

- Do not collect urine from the pouch with the patient with a urinary diversion (e.g., ileal conduit). Instead, perform catheterization through the stoma.

Timed Specimen:

- Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same time the collection was begun.
- At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- Include on the collection container's label the amount of urine, test start and stop times, and any foods or medications that can affect test results.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume usual diet, medications, and activity, as directed by the HCP.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the NKF (www.kidney.org) or the NKDEP (www.nkdep.nih.gov).
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include anion gap, antibiotic drugs, antibodies antiglomerular basement membrane, ANF, biopsy kidney, biopsy muscle, blood gases, BNP, BUN, calcium, calculus kidney stone analysis, C4, CT abdomen, CT renal, CK and isoenzymes, creatinine, culture urine, cytology urine, cystoscopy, echocardiography, echocardiography transesophageal, electrolytes, EMG, ENG, EPO, gallium scan, glucagon, glucose, haptoglobin, insulin, IVP, KUB studies, lung perfusion scan, microalbumin, osmolality, phosphorus, renogram, retrograde ureteropyelography, TSH, thyroglobin, US kidney, uric acid, and UA.
- Refer to the Genitourinary System table at the end of the book for related tests by body system.

Cryoglobulin

SYNONYM/ACRONYM: Cryo.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Visual observation for changes in appearance)
Negative.

DESCRIPTION: Cryoglobulins are abnormal serum proteins that cannot be detected by protein electrophoresis. Cryoglobulins cause vascular problems because they can precipitate in the blood vessels of the fingers when exposed to cold, causing Raynaud's phenomenon. They are usually associated with immunological disease. The laboratory procedure to detect cryoglobulins is a two-step process. The serum sample is observed for cold precipitation after 72 hr of storage at 4°C. True cryoglobulins disappear on warming to room temperature, so in the second step of the procedure, the sample is rewarmed to confirm reversibility of the reaction.

INDICATIONS:

- Assist in diagnosis of neoplastic diseases, acute and chronic infections, and collagen diseases
- Detect cryoglobulinemia in patients with symptoms indicating or mimicking Raynaud's disease
- Monitor course of collagen and rheumatic disorders

RESULT:

Increased in:

- Type I cryoglobulin (monoclonal)
Chronic lymphocytic leukemia

Lymphoma
Multiple myeloma

- Type II cryoglobulin (mixtures of monoclonal immunoglobulin [Ig] M and polyclonal IgG)
Autoimmune hepatitis
Rheumatoid arthritis
Sjögren's syndrome
Waldenström's macroglobulinemia
- Type III cryoglobulin (mixtures of polyclonal IgM and IgG)
Acute poststreptococcal glomerulonephritis
Chronic infection (especially hepatitis C)
Cirrhosis
Endocarditis
Infectious mononucleosis
Polymyalgia rheumatica
Rheumatoid arthritis
Sarcoidosis
Systemic lupus erythematosus

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Testing the sample prematurely (before total precipitation) may yield incorrect results.
- Failure to maintain sample at normal body temperature before centrifugation can affect results.
- A recent fatty meal can increase turbidity of the blood, decreasing visibility.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to assist in identification the presence of certain immunological disorders.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune system as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, ANA, arthroscopy, AST, bilirubin, biopsy liver, bone scan, ceruloplasmin, copper, CRP, ESR, GGT, infectious mono screen, hepatitis C antibody, IgA, IgG, IgM, IFE, liver and spleen scan, protein, protein electrophoresis, RF, synovial fluid analysis, and US liver.
- ▶ Refer to the Immune System table at the end of the book for related tests by body system.

Culture and Smear, Mycobacteria

SYNONYM/ACRONYM: Acid-fast bacilli (AFB) culture and smear, tuberculosis (TB) culture and smear, *Mycobacterium* culture and smear.

SPECIMEN: Sputum (5 to 10 mL), bronchopulmonary lavage, tissue, material from fine-needle aspiration, bone marrow, cerebrospinal fluid (CSF), gastric aspiration, urine, and stool.

REFERENCE VALUE: (Method: Culture on selected media, microscopic examination of sputum by acid-fast or auramine-rhodamine fluorochrome stain) Rapid methods include: chemiluminescent-labeled DNA probes that target ribosomal RNA of the *Mycobacterium* radiometric carbon dioxide detection from ¹⁴C-labeled media, polymerase chain reaction/amplification techniques.

Culture: No growth

Smear: Negative for AFB

DESCRIPTION: A culture and smear test is used primarily to detect *Mycobacterium tuberculosis*, which is a tubercular bacillus. The cell wall of this mycobacterium contains complex lipids and waxes that do not take up ordinary stains. Cells that resist decolorization by acid alcohol are termed *acid-fast*. There are only a few groups of acid-fast bacilli (AFB); this characteristic is helpful in rapid identification so that therapy can be initiated in a timely manner. Smears may be negative 50% of the time even though the culture develops positive growth 3 to 8 wk later. AFB cultures are used to confirm positive and negative AFB smears. *M. tuberculosis* grows in culture slowly. Automated liquid culture systems, such as the Bactec and MGIT (Becton Dickinson and Company, 1 Becton Drive, Franklin Lakes, NJ, 07417), have a turnaround time of approximately 10 days. Results of tests

by polymerase chain reaction culture methods are available in 24 to 72 hr.

M. tuberculosis is transmitted via the airborne route to the lungs. It causes areas of granulomatous inflammation, cough, fever, and hemoptysis. It can remain dormant in the lungs for long periods. The incidence of tuberculosis has increased since the late 1980s in depressed inner-city areas, among prison populations, and among HIV-positive patients. Of great concern is the increase in antibiotic-resistant strains. HIV-positive patients often become ill from concomitant infections caused by *M. tuberculosis* and *Mycobacterium avium intracellulare*. *M. avium intracellulare* is acquired via the gastrointestinal tract through ingestion of contaminated food or water. The organism's waxy cell wall protects it from acids in the human digestive tract. Isolation of mycobacteria in the

stool does not mean the patient has tuberculosis of the intestines because mycobacteria in stool are most often present in sputum that has been swallowed.

INDICATIONS:

- Assist in the diagnosis of mycobacteriosis

RESULT:

Identified Organism	Primary Specimen Source	Condition
<i>Mycobacterium avium intracellulare</i>	CSF, lymph nodes, semen, sputum, urine	Opportunistic pulmonary infection
<i>M. fortuitum</i>	Bone, body fluid, sputum, surgical wound, tissue	Opportunistic infection (usually pulmonary)
<i>M. leprae</i>	CSF, skin scrapings, lymph nodes	Hanson's disease (leprosy)
<i>M. kansasii</i>	Joint, lymph nodes, skin, sputum	Pulmonary tuberculosis
<i>M. marinum</i>	Joint	Granulomatus skin lesions
<i>M. tuberculosis</i>	CSF, gastric washing, sputum, urine	Pulmonary tuberculosis
<i>M. xenopi</i>	Sputum	Pulmonary tuberculosis

CRITICAL VALUES:

- **Smear:** Positive for AFB
- **Culture:** Growth of pathogenic bacteria

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

- Specimen collection after initiation of treatment with antituberculosis drug therapy may result in inhibited or no growth of organisms.
- Contamination of the sterile container with organisms from an exogenous source may produce misleading results.
- Specimens received on a dry swab should be rejected: A dry swab

- Assist in the diagnosis of suspected pulmonary tuberculosis secondary to AIDS
- Assist in the differentiation of tuberculosis from carcinoma or bronchiectasis
- Investigate suspected pulmonary tuberculosis
- Monitor the response to treatment for pulmonary tuberculosis

indicates that the sample is unlikely to have been collected properly or unlikely to contain a representative quantity of significant organisms for proper evaluation.

- Inadequate or improper (e.g., saliva) samples should be rejected.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is primarily used to assist in the diagnosis of tuberculosis.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex. Obtain a history of the patient's exposure to tuberculosis.
- ▶ Obtain a history of the patient's immune and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Review the procedure with the patient. Reassure the patient that he or she will be able to breathe during the procedure if sputum specimen collection is accomplished via suction method. Ensure that oxygen has been administered 20 to 30 min before the procedure if the specimen is to be obtained by tracheal suction. Address concerns about pain related to the procedure. Atropine is usually given before bronchoscopy examinations to reduce bronchial secretions and prevent vagally induced bradycardia. Meperidine (Demerol) or morphine may be given as a sedative. Lidocaine is sprayed in the patient's throat to reduce discomfort caused by the presence of the tube.
- ▶ Explain to the patient that the time it takes to collect a proper specimen varies according to the level of cooperation of the patient and the specimen collection site. Emphasize that sputum and saliva are not the same. Inform the patient that multiple specimens may be required at timed intervals. Inform the patient that the culture results will not be reported for 3 to 8 wk.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

Bronchoscopy:

- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

- ▶ Other than antimicrobial drugs, there are no medication restrictions, unless by medical direction.
- ▶ The patient should fast and refrain from drinking liquids beginning at midnight the night before the procedure. Protocols may vary from facility to facility.

Expectorated Specimen:

- ▶ Additional liquids the night before may assist in liquefying secretions during expectoration the following morning.
- ▶ Assist the patient with oral cleaning before sample collection to reduce the amount of sample contamination by organisms that normally inhabit the mouth.
- ▶ Instruct the patient not to touch the edge or inside of the container with the hands or mouth.
- ▶ Other than antimicrobial drugs, there are no medication restrictions, unless by medical direction.
- ▶ There are no food or fluid restrictions, unless by medical direction.

Tracheal Suctioning:

- ▶ Assist in providing extra fluids, unless contraindicated, and proper humidification to decrease tenacious secretions. Inform the patient that increasing fluid intake before retiring on the night before the test aids in liquefying secretions and may make it easier to expectorate in the morning. Also explain that humidifying inspired air also helps liquefy secretions.
- ▶ Other than antimicrobial drugs, there are no medication restrictions, unless by medical direction.
- ▶ There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions; assure that food and fluids have been restricted for at least 8 hr prior to the bronchoscopy procedure.
- ▶ Have patient remove dentures, contact lenses, eyeglasses, and jewelry. Notify the HCP if the patient has permanent crowns on teeth. Have the patient remove clothing and change into a gown for the procedure.
- ▶ Have emergency equipment readily available. Keep resuscitation equipment on hand in case of respiratory

impairment or laryngospasm after the procedure.

- ▶ Avoid using morphine sulfate in patients with asthma or other pulmonary disease. This drug can further exacerbate bronchospasms and respiratory impairment.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Assist the patient to a comfortable position, and direct the patient to breathe normally during the beginning of the local anesthesia. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date and time of collection, and any medication the patient is taking that may interfere with test results (e.g., antibiotics).

Bronchoscopy:

- ▶ Record baseline vital signs.
- ▶ The patient is positioned in relation to the type of anesthesia being used. If local anesthesia is used, the patient is seated and the tongue and oropharynx are sprayed and swabbed with anesthetic before the bronchoscope is inserted. For general anesthesia, the patient is placed in a supine position with the neck hyperextended. After anesthesia, the patient is kept in supine or shifted to a side-lying position and the bronchoscope is inserted. After inspection, the samples are collected from suspicious sites by bronchial brush or biopsy forceps.

Expectorated Specimen:

- ▶ Ask the patient to sit upright, with assistance and support (e.g., with an overbed table) as needed.
- ▶ Ask the patient to take two or three deep breaths and cough deeply. Any sputum raised should be expectorated directly into a sterile sputum collection container.
- ▶ If the patient is unable to produce the desired amount of sputum, several

strategies may be attempted. One approach is to have the patient drink two glasses of water, and then assume the position for postural drainage of the upper and middle lung segments. Effective coughing may be assisted by placing either the hands or a pillow over the diaphragmatic area and applying slight pressure.

- ▶ Another approach is to place a vaporizer or other humidifying device at the bedside. After sufficient exposure to adequate humidification, postural drainage of the upper and middle lung segments may be repeated before attempting to obtain the specimen.
- ▶ Other methods may include obtaining an order for an expectorant to be administered with additional water approximately 2 hr before attempting to obtain the specimen. Chest percussion and postural drainage of all lung segments may also be employed. If the patient is still unable to raise sputum, the use of an ultrasonic nebulizer ("induced sputum") may be necessary; this is usually done by a respiratory therapist.

Tracheal Suctioning:

- ▶ Obtain the necessary equipment, including a suction device, suction kit, and Lukens tube or in-line trap.
- ▶ Position the patient with head elevated as high as tolerated.
- ▶ Put on sterile gloves. Maintain the dominant hand as sterile and the non-dominant hand as clean.
- ▶ Using the sterile hand, attach the suction catheter to the rubber tubing of the Lukens tube or in-line trap. Then attach the suction tubing to the male adapter of the trap with the clean hand. Lubricate the suction catheter with sterile saline.
- ▶ Tell nonintubated patients to protrude the tongue and to take a deep breath as the suction catheter is passed through the nostril. When the catheter enters the trachea, a reflex cough is stimulated; immediately advance the catheter into the trachea and apply suction. Maintain suction for approximately 10 sec, but never longer than 15 sec. Withdraw the catheter without applying suction. Separate the suction

catheter and suction tubing from the trap, and place the rubber tubing over the male adapter to seal the unit.

- For intubated patients or patients with a tracheostomy, the previous procedure is followed except that the suction catheter is passed through the existing endotracheal or tracheostomy tube rather than through the nostril. The patient should be hyperoxygenated before and after the procedure in accordance with standard protocols for suctioning these patients.
- Generally, a series of three to five early morning sputum samples are collected in sterile containers. If leprosy is suspected, obtain a smear from nasal scrapings or a biopsy specimen from lesions in a sterile container.

General:

- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- Inform the patient that he or she may experience some throat soreness and hoarseness. Instruct patient to treat throat discomfort with lozenges and warm gargles when the gag reflex returns.
- Monitor vital signs and compare with baseline values every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- Emergency resuscitation equipment should be readily available if the vocal cords become spastic after intubation.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.

- Observe the patient for hemoptysis, difficulty breathing, cough, air hunger, excessive coughing, pain, or absent breathing sounds over the affected area. Report any symptoms to the HCP.
- Evaluate the patient for symptoms indicating the development of pneumothorax, such as dyspnea, tachypnea, anxiety, decreased breathing sounds, or restlessness. A chest x-ray may be ordered to check for the presence of this complication.
- Evaluate the patient for symptoms of empyema, such as fever, tachycardia, malaise, or elevated white blood cell count.
- Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Nutritional considerations:** Malnutrition is commonly seen in patients with severe respiratory disease for numerous reasons, including fatigue, lack of appetite, and gastrointestinal distress. Adequate intake of vitamins A and C are also important to prevent pulmonary infection and to decrease the extent of lung tissue damage.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient to use lozenges or gargle for throat discomfort. Inform the patient of smoking cessation programs as appropriate. The importance of following the prescribed diet should be stressed to the patient/caregiver. Educate the patient regarding access to counseling services, as appropriate. Answer any questions or address any concerns voiced by the patient or family.
- Instruct the patient in the use of any ordered medications. Explain the

importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.

- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antibodies, anti-glomerular basement membrane, arterial/alveolar oxygen ratio, blood gases, bronchoscopy, chest x-ray, complete blood count, CT thoracic, cultures (fungal, sputum, throat, viral), cytology sputum, gallium scan, gram stain, lung perfusion scan, lung ventilation scan, MRI chest, mediastinoscopy, pleural fluid analysis, pulmonary function tests, and TB tests.
- Refer to the Immune and Respiratory System tables at the end of the book for related tests by body system.

Culture, Bacterial, Anal/Genital, Ear, Eye, Skin, and Wound

SYNONYM/ACRONYM: N/A.

SPECIMEN: Sterile fluid or swab from affected area placed in transport media tube provided by laboratory.

REFERENCE VALUE: (Method: Culture aerobic and/or anaerobic on selected media; DNA probe assays (e.g., *Gen-Probe*) are available for identification of *Neisseria gonorrhoeae* and *Chlamydia trachomatis*. Negative: no growth of pathogens.

DESCRIPTION: When indicated by patient history, anal and genital cultures may be performed to isolate the organism responsible for sexually transmitted disease. Group B Streptococcus (GBS) is a significant and serious neonatal infection. CDC recommends universal GBS screening for all pregnant women at 35 to 37 wk gestation. Rapid GBS test kits can provide results within minutes on vaginal or rectal fluid swab specimens submitted in a sterile red-top tube.

Ear and eye cultures are performed to isolate the organism responsible for chronic or acute infectious disease of the ear and eye.

Skin and soft tissue samples from infected sites must be collected carefully to avoid contamination from the surrounding normal skin flora. Skin and tissue infections may be caused by both aerobic and anaerobic organisms. Therefore, a portion of the sample should be placed in aerobic and a portion in anaerobic transport media.

Care must be taken to use transport media that are approved by the laboratory performing the testing.

Sterile fluids can be collected from the affected site. Refer to related body fluid monographs (i.e., amniotic fluid, cerebrospinal fluid, pericardial fluid, peritoneal fluid, pleural fluid, synovial fluid) for specimen collection.

A wound culture involves collecting a specimen of exudates, drainage, or tissue so that the causative organism can be isolated and pathogens identified. Specimens can be obtained from superficial and deep wounds.

Optimally, specimens should be obtained before antibiotic use. The method used to culture and grow the organism depends on the suspected infectious organism. There are transport media specifically for bacterial agents. The laboratory will select the appropriate media for suspect organisms. The laboratory will initiate antibiotic sensitivity testing if indicated by test results. Sensitivity testing identifies the antibiotics to which organisms are susceptible to ensure an effective treatment plan.

INDICATIONS:

Anal/Genital:

- Assist in the diagnosis of sexually transmitted diseases
- Determine the cause of genital itching or purulent drainage
- Determine effective antimicrobial therapy specific to the identified pathogen
- Routine prenatal screening for vaginal and rectal GBS colonization

Ear:

- Isolate and identify organisms responsible for ear pain, drainage, or changes in hearing
- Isolate and identify organisms responsible for outer-, middle-, or inner-ear infection
- Determine effective antimicrobial therapy specific to the identified pathogen

Eye:

- Isolate and identify pathogenic microorganisms responsible for infection of the eye
- Determine effective antimicrobial therapy specific to identified pathogen

Skin:

- Isolate and identify organisms responsible for skin eruptions, drainage, or other evidence of infection
- Determine effective antimicrobial therapy specific to the identified pathogen

Sterile Fluids:

- Isolate and identify organisms before surrounding tissue becomes infected
- Determine effective antimicrobial therapy specific to the identified pathogen

Wound:

- Detect abscess or deep-wound infectious process
- Determine if an infectious agent is the cause of wound redness, warmth, or edema with drainage at a site
- Determine presence of infectious agents in a stage 3 and stage 4 decubitus ulcer
- Isolate and identify organisms responsible for the presence of pus or other exudate in an open wound

- Determine effective antimicrobial therapy specific to the identified pathogen

RESULT:

Positive findings in:

Anal/Endocervical/Genital:

Infections or carrier states are caused by the following organisms: *Chlamydia trachomatis*, Gardnerella vaginalis, *N. gonorrhoeae*, toxin-producing strains of *Staphylococcus aureus*, Group B *Streptococcus*, and *Treponema pallidum*.

Ear:

Commonly identified organisms include *Escherichia coli*, *Proteus* spp., *Pseudomonas aeruginosa*, *S. aureus*, and β -hemolytic streptococci.

Eye:

Commonly identified organisms include *Chlamydia trachomatis* (transmitted to newborns from infected mothers), *Haemophilus influenzae* (transmitted to newborns from infected mothers), *H. aegyptius*, *N. gonorrhoeae* (transmitted to newborns from infected mothers), *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Streptococcus pneumoniae*.

Skin:

Commonly identified organisms include *Bacteroides*, *Clostridium*, *Corynebacterium*, *Pseudomonas*, staphylococci, and group A streptococci.

Sterile Fluids:

Commonly identified pathogens include *Bacteroides*, *Enterococcus* spp., *E. coli*, *Pseudomonas aeruginosa*, and *Peptostreptococcus* spp.

Wound:

Aerobic and anaerobic microorganisms can be identified in wound culture specimens. Commonly identified organisms include *Clostridium perfringens*, *Klebsiella*, *Proteus*, *Pseu-*

domonas, *Staphylococcus aureus*, and group A streptococci.

CRITICAL VALUES:

- *Listeria* in genital cultures
- Methicillin resistant *Staphylococcus aureus* (MRSA) in skin or wound cultures

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

- Failure to collect adequate specimen, improper collection or storage technique, and failure to transport specimen in a timely fashion are causes for specimen rejection.
- Pretest antimicrobial therapy will delay or inhibit the growth of pathogens.
- Testing specimens more than 1 hr after collection may result in decreased growth or no growth of organisms.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify pathogenic bacterial organisms.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain, as appropriate, a history of sexual activity.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent medications that can interfere with test results.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 min. Address concerns about pain and explain that there may be some discomfort during the specimen collection. Instruct female patients not to douche for 24 hr before a cervical or vaginal specimen is to be obtained.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions prior to the procedure.
 - ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
 - ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate specimen containers with the corresponding patient demographics, specimen source (left or right as appropriate), patient age and gender, date and time of collection, and any medication the patient is taking that may interfere with the test results (e.g., antibiotics). Do not freeze the specimen or allow it to dry.
- Anal:**
- ▶ Place the patient in a lithotomy or side-lying position and drape for privacy. Insert the swab 1 in. into the anal canal and rotate, moving it from side to side to allow it to come into contact with the microorganisms. Remove the swab. Place the swab in the Culturette tube, and squeeze the bottom of the tube to release the transport medium. Ensure that the end of the swab is immersed in
- the medium. Repeat with a clean swab if the swab is pushed into feces.
- Genital:**
- Female Patient:**
- ▶ Position the patient on the gynecological examination table with the feet up in stirrups. Drape the patient's legs to provide privacy and reduce chilling.
 - ▶ Cleanse the external genitalia and perineum from front to back with towlettes provided in culture kit. Using a Culturette swab, obtain a sample of the lesion or discharge from the urethra or vulva. Place the swab in the Culturette tube, and squeeze the bottom of the tube to release the transport medium. Ensure that the end of the swab is immersed in the medium.
 - ▶ To obtain a vaginal and endocervical culture, insert a water-lubricated vaginal speculum. Insert the swab into the cervical orifice and rotate the swab to collect the secretions containing the microorganisms. Remove and place in the appropriate culture medium or Gen-Probe transport tube. Material from the vagina can be collected by moving a swab along the sides of the vaginal mucosa. The swab is removed and then placed in a tube of saline medium.
- Male Patient:**
- ▶ To obtain a urethral culture, cleanse the penis (retracting the foreskin), have the patient milk the penis to express discharge from the urethra. Insert a swab into the urethral orifice and rotate the swab to obtain a sample of the discharge. Place the swab in the Culturette or Gen-Probe transport tube, and squeeze the bottom of the tube to release the transport medium. Ensure that the end of the swab is immersed in the medium.
- Ear:**
- ▶ Cleanse the area surrounding the site with a swab containing cleaning solution to remove any contaminating material or flora that have collected in the ear canal. If needed, assist the appropriate health care provider (HCP)

in removing any cerumen that has collected.

- ▶ Insert a Culturette swab approximately $\frac{1}{4}$ in. into the external ear canal. Rotate the swab in the area containing the exudate. Carefully remove the swab, ensuring that it does not touch the side or opening of the ear canal.
- ▶ Place the swab in the Culturette tube, and squeeze the bottom of the tube to release the transport medium. Ensure that the end of the swab is immersed in the medium.

Eye:

- ▶ Pass a moistened swab over the appropriate site, avoiding eyelid and eyelashes unless those areas are selected for study. Collect any visible pus or other exudate. Place the swab in the Culturette or Gen-Probe transport tube, and squeeze the bottom of the tube to release the transport medium. Ensure that the end of the swab is immersed in the medium.
- ▶ An appropriate HCP should perform procedures requiring eye scrapings.

Skin:

- ▶ Assist the appropriate HCP in obtaining a skin sample from several areas of the affected site. If indicated, the dark, moist areas of the folds of the skin and outer growing edges of the infection where microorganisms are most likely to flourish should be selected. Place the scrapings in a collection container or spread on a slide. Aspirate any fluid from a pustule or vesicle using a sterile needle and tuberculin syringe. The exudate will be flushed into a sterile collection tube. If the lesion is not fluid filled, open the lesion with a scalpel and swab the area with a sterile cotton-tipped swab. Place the swab in the Culturette tube, and squeeze the bottom of the tube to release the transport medium. Ensure that the end of the swab is immersed in the medium.

Sterile Fluid:

- ▶ Refer to related body fluid monographs (i.e., amniotic fluid, cerebrospinal fluid, pericardial fluid, peritoneal fluid, pleural

fluid, synovial fluid) for specimen collection.

Wound:

- ▶ Place the patient in a comfortable position, and drape the site to be cultured. Cleanse the area around the wound to remove flora indigenous to the skin.
- ▶ Place a Culturette swab in a superficial wound where the exudate is the most excessive without touching the wound edges. Place the swab in the Culturette tube, and squeeze the bottom of the tube to release the transport medium. Ensure that the end of the swab is immersed in the medium. Use more than one swab and Culturette tube to obtain specimens from other areas of the wound.
- ▶ To obtain a deep wound specimen, insert a sterile syringe and needle into the wound and aspirate the drainage. Following aspiration, inject the material into a tube containing an anaerobic culture medium.

General:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ Instruct the patient to resume usual medication as directed by the HCP.
- ▶ Instruct the patient to report symptoms such as pain related to tissue inflammation or irritation.
- ▶ Instruct the patient to begin antibiotic therapy, as prescribed. Instruct the patient in the importance of completing the entire course of antibiotic therapy even if no symptoms are present.
- ▶ Inform the patient that a repeat culture may be needed in 1 wk after completion of the antimicrobial regimen.
- ▶ Advise the patient that final test results may take 24 to 72 hr depending on the organism suspected, but that antibiotic therapy may be started immediately.

Anal/Endocervical/Genital:

- ▶ Inform the patient that final results may take from 24 hr to 4 wk, depending on the test performed.

- ◆ Advise the patient to avoid sexual contact until test results are available.
- ◆ Instruct the patient in vaginal suppository and medicated cream installation and administration of topical medication to treat specific conditions, as indicated.
- ◆ Inform infected patients that all sexual partners must be tested for the microorganism.
- ◆ Inform the patient that positive culture findings for certain organisms must be reported to a local health department official, who will question him or her regarding sexual partners.
- ◆ **Social and cultural considerations:** Offer support, as appropriate, to patients who may be the victims of rape or sexual assault. Educate the patient regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for discussing the risks of sexually transmitted diseases. It is also important to address problems the patient may experience (e.g., guilt, depression, anger).

Wound:

- ◆ Instruct the patient in wound care and nutritional requirements (e.g., protein, vitamin C) to promote wound healing.

General:

- ◆ A written report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Emphasize the importance of reporting continued signs and symptoms of the infection. Provide information regarding vaccine-preventable diseases where indicated (e.g., hepatitis A and B, human papillomavirus). Answer any questions or address any concerns voiced by the patient or family.
- ◆ Instruct the patient in the use of any ordered medications (oral, topical, drops). Instruct the patient in the proper use of sterile technique for cleansing the affected site and application of dressings, as directed. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include relevant biopsy site, CSF analysis, culture viral, gram stain, vitamin C, pericardial fluid analysis, amniotic fluid analysis, PAP smear, peritoneal fluid analysis, pleural fluid analysis, synovial fluid analysis, syphilis serology, and zinc.
- ◆ Refer to the Immune System table at the end of the book for related tests by body system.

Culture, Bacterial, Blood

SYNONYM/ACRONYM: N/A.

SPECIMEN: Whole blood collected in bottles containing standard aerobic and anaerobic culture media; 10 to 20 mL for adult patients or 1 to 5 mL for pediatric patients.

REFERENCE VALUE: (Method: Growth of organisms in standard culture media identified by radiometric or infrared automation, or by manual reading of subculture.) Negative: no growth of pathogens.

DESCRIPTION: Blood cultures are collected whenever bacteremia or septicemia is suspected. Although mild bacteremia is found in many infectious diseases, a persistent, continuous, or recurrent bacteremia indicates a more serious condition that may require immediate treatment. Early detection of pathogens in the blood may aid in making clinical and etiological diagnoses.

Blood culture involves the introduction of a specimen of blood into artificial aerobic and anaerobic growth culture medium. The culture is incubated for a specific length of time, at a specific temperature, and under other conditions suitable for the growth of pathogenic microorganisms. Pathogens enter the bloodstream from soft-tissue infection sites, contaminated IV lines, or invasive procedures (e.g., surgery, tooth extraction, cystoscopy). A blood culture may also be done with an antimicrobial removal device (ARD). This involves transferring some of the blood sample into a special vial containing absorbent resins that remove

antibiotics from the sample before the culture is performed. The laboratory will initiate antibiotic sensitivity testing if indicated by test results. Sensitivity testing identifies the antibiotics to which the organisms are susceptible to ensure an effective treatment plan.

INDICATIONS:

- Determine sepsis in the newborn as a result of prolonged labor, early rupture of membranes, maternal infection, or neonatal aspiration
- Evaluate chills and fever in patients with infected burns, urinary tract infections, rapidly progressing tissue infection, postoperative wound sepsis, and indwelling venous or arterial catheter
- Evaluate intermittent or continuous temperature elevation of unknown origin
- Evaluate persistent, intermittent fever associated with a heart murmur
- Evaluate a sudden change in pulse and temperature with or without chills and diaphoresis


- Evaluate suspected bacteremia after invasive procedures
- Identify the cause of shock in the postoperative period

RESULT:

Positive findings in:

- Bacteremia or septicemia: *Aerobacter*, *Bacteroides*, *Brucella*, *Clostridium perfringens*, enterococci, *Escherichia coli* and other coliform bacilli, *Haemophilus influenzae*, *Klebsiella*, *Listeria monocytogenes*, *Pseudomonas aeruginosa*, *Salmonella*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, and β -hemolytic streptococci.
- Plague
- Malaria (by special request, a stained capillary smear would be examined)
- Typhoid fever

Note: *Candida albicans* is a yeast that can cause disease and can be isolated by blood culture.

CRITICAL VALUES:  Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

- Pretest antimicrobial therapy will delay or inhibit growth of pathogens.
- Contamination of the specimen by the skin's resident flora may invalidate interpretation of test results.
- An inadequate amount of blood or number of blood specimens drawn for examination may invalidate interpretation of results.
- Testing specimens more than 1 hr after collection may result in decreased growth or no growth of organisms.
- Negative findings do not ensure the absence of infection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify pathogenic bacterial organisms.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to iodine.
- ▶ Obtain a history of the patient's immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent medications that can interfere with test results.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 min. Inform the patient that multiple specimens may be required at timed intervals. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions prior to the procedure.
- ▶ If the patient has a history of severe allergic reaction to iodine, care should be taken to avoid the use of iodine.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the

patient, and label the appropriate specimen containers with the corresponding patient demographics, date and time of collection, and any medication the patient is taking that may interfere with test results (e.g., antibiotics). Perform a venipuncture; collect the specimen in the appropriate blood culture collection container.

- ▶ The high risk for infecting a patient by venipuncture can be decreased by using an aseptic technique during specimen collection.
- ▶ The contamination of blood cultures by skin and other flora can also be dramatically reduced by careful preparation of the puncture site and collection containers before specimen collection. Cleanse the rubber stoppers of the collection containers with the appropriate disinfectant as recommended by the laboratory, allow to air-dry, and cleanse with 70% alcohol. Once the vein has been located by palpation, cleanse the site with 70% alcohol followed by swabbing with an iodine solution. The iodine should be swabbed in a circular concentric motion, moving outward or away from the puncture site. The iodine should be allowed to completely

dry before the sample is collected. If the patient is sensitive to iodine, a double alcohol scrub or green soap may be substituted.

- ▶ If collection is performed by directly drawing the sample into a culture tube, fill the aerobic culture tube first.
- ▶ If collection is performed using a syringe, transfer the blood sample directly into each culture bottle.
- ▶ Remove the needle, and apply direct pressure with a dry gauze to stop bleeding. Observe venipuncture site for bleeding and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.
- ▶ More than three sets of cultures per day do not significantly add to the likelihood of pathogen capture. Capture rates are more likely affected by obtaining a sufficient volume of blood per culture.
- ▶ The use of ARDs or resin bottles is costly and controversial with respect to their effectiveness versus standard culture techniques. They may be useful in selected cases, such as when septicemia or bacteremia is suspected after antimicrobial therapy has been initiated.

Disease Suspected

Recommended Collection

Bacterial pneumonia, fever of unknown origin, meningitis, osteomyelitis, sepsis

2 sets of cultures; each collected from a separate site, 30 min apart

Acute or subacute endocarditis

3 sets of cultures; each collected from a separate site, 60 min apart. If cultures are negative after 24 to 48 hr, repeat collections

Septicemia, fungal or mycobacterial infection in immunocompromised patient

2 sets of cultures; each collected from a separate site, 30 to 60 min apart (laboratory may use a lysis concentration technique to enhance recovery)

Septicemia, bacteremia after therapy has been initiated or request to monitor effectiveness of antimicrobial therapy

2 sets of cultures; each collected from a separate site, 30 to 60 min apart (consider use of ARD to enhance recovery)

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medication as directed by the HCP.
- ▶ Cleanse the iodine from the collection site.
- ▶ Instruct the patient to report symptoms such as pain related to tissue inflammation or irritation.
- ▶ Instruct the patient to report fever, chills, and other signs and symptoms of acute infection to the HCP.
- ▶ Instruct the patient to begin antibiotic therapy, as prescribed. Instruct the patient in the importance of completing the entire course of antibiotic therapy even if no symptoms are present.
- ▶ Inform the patient that preliminary results should be available in 24 to 72 hr, but final results are not available for 5 to 7 days.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Emphasize the importance of reporting, continued signs and symptoms of the infection. Provide information regarding vaccine-preventable diseases where indicated (e.g., influenza, meningococcal, pneumococcal). Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include bone scan, bronchoscopy, complete blood count, cultures (fungal, mycobacteria, throat, sputum, viral), CSF analysis, ESR, gallium scan, gram stain, HIV-1/2 antibodies, MRI musculoskeletal, PFT, radiography bone, and TB tests.
- ▶ Refer to the Immune System table at the end of the book for related tests by body system.

Culture, Bacterial, Sputum

SYNONYM/ACRONYM: Routine culture of sputum.

SPECIMEN: Sputum (10 to 15 mL).

REFERENCE VALUE: (Method: Aerobic culture on selective and enriched media; microscopic examination of sputum by Gram stain.) The presence of normal upper respiratory tract flora should be expected. Tracheal aspirates and bronchoscopy samples can be contaminated with normal flora, but transtracheal aspiration specimens should show no growth. Normal respiratory flora include *Neisseria catarrhalis*, *Candida albicans*, diphtheroids, α -hemolytic streptococci, and some staphylococci. The presence of normal flora does not rule out infection. A normal Gram stain of sputum contains polymorphonuclear leukocytes, alveolar macrophages, and a few squamous epithelial cells.

DESCRIPTION: This test involves collecting a sputum specimen so the pathogen can be isolated and identified. The test results will reflect the type and number of organisms present in the specimen, as well as the antibiotics to which the identified pathogenic organisms are susceptible. Sputum collected by expectoration or suctioning with catheters and by bronchoscopy cannot be cultured for anaerobic organisms; instead, transtracheal aspiration or lung biopsy must be used. The laboratory will initiate antibiotic sensitivity testing if indicated by test results. Sensitivity testing identifies antibiotics to which the organisms are susceptible to ensure an effective treatment plan.

INDICATIONS:

Culture:

- Assist in the diagnosis of respiratory infections, as indicated by the presence or absence of organisms in culture

Gram stain:

- Assist in the differentiation of gram-positive from gram-negative bacteria in respiratory infection
- Assist in the differentiation of sputum from upper respiratory tract secretions, the latter being indicated by excessive squamous cells or absence of polymorphonuclear leukocytes

RESULT:

- The major difficulty in evaluating results is in distinguishing organisms infecting the lower respiratory tract from organisms that have colonized but not infected the lower respiratory tract. Review of the

Gram stain assists in this process. The presence of greater than 25 squamous epithelial cells per low-power field (lpf) indicates oral contamination, and the specimen should be rejected. The presence of many polymorphonuclear neutrophils and few squamous epithelial cells indicates that the specimen was collected from an area of infection and is satisfactory for further analysis.

- Bacterial pneumonia can be caused by *Streptococcus pneumoniae*, *Haemophilus influenzae*, staphylococci, and some gram-negative bacteria. Other pathogens that can be identified by culture are *Corynebacterium diphtheriae*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*. Some infectious agents, such as *C. diphtheriae*, are more fastidious in their growth requirements and cannot be cultured and identified without special treatment. Suspicion of infection by less commonly identified and/or fastidious organisms must be communicated to the laboratory to ensure selection of the proper procedure required for identification.

CRITICAL VALUES:

- *Corynebacterium diphtheriae*
- *Legionella*

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

- Contamination with oral flora may invalidate results.
- Specimen collection after antibiotic therapy has been initiated may result in inhibited or no growth of organisms.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify pathogenic bacterial organisms.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent medications that can interfere with test results.
- ▶ Review the procedure with the patient. Reassure the patient that he or she will be able to breathe during the procedure if specimen collection is accomplished via suction method. Ensure that oxygen has been administered 20 to 30 min before the procedure if the specimen is to be obtained by tracheal suctioning. Address concerns about pain related to the procedure. Atropine is usually given before bronchoscopy examinations to reduce bronchial secretions and prevent vagally induced bradycardia. Meperidine (Demerol) or morphine may be given as a sedative. Lidocaine is sprayed in the patient's throat to reduce discomfort caused by the presence of the tube.
- ▶ Explain to the patient that the time it takes to collect a proper specimen varies according to the level of cooperation of the patient and the specimen collection site. Emphasize that sputum and saliva are not the same. Inform the patient that multiple specimens may be required at timed intervals.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

Bronchoscopy:

- ▶ *Make sure a written and informed consent has been signed prior to the bronchoscopy/biopsy procedure and before administering any medications.*
- ▶ Other than antimicrobial drugs, there are no medication restrictions, unless by medical direction.
- ▶ The patient should fast and refrain from drinking liquids beginning at midnight the night before the procedure. Protocols may vary from facility to facility.

Expectorated Specimen:

- ▶ Additional liquids the night before may assist in liquefying secretions during expectoration the following morning.
- ▶ Assist the patient with oral cleaning before sample collection to reduce the amount of sample contamination by organisms that normally inhabit the mouth.
- ▶ Instruct the patient not to touch the edge or inside of the container with the hands or mouth.
- ▶ Other than antimicrobial drugs, there are no medication restrictions, unless by medical direction.
- ▶ There are no food or fluid restrictions, unless by medical direction.

Tracheal Suctioning:

- ▶ Assist in providing extra fluids, unless contraindicated, and proper humidification to decrease tenacious secretions. Inform the patient that increasing fluid intake before retiring on the night before the test aids in liquefying secretions and may make it easier to expectorate in the morning. Also explain that humidifying inspired air also helps liquefy secretions.
- ▶ Other than antimicrobial drugs, there are no medication restrictions, unless by medical direction.
- ▶ There are no food or fluid restrictions, unless by medical direction.
- ▶ If the specimen is collected by expectoration or tracheal suctioning, there are no food, fluid, or medication restrictions (except antibiotics), unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions; assure that food and fluids have been restricted for at least 8 hr prior to the bronchoscopy procedure.

- ▶ Have patient remove dentures, contact lenses, eyeglasses, and jewelry. Notify the health care provider (HCP) if the patient has permanent crowns on teeth. Have the patient remove clothing and change into a gown for the procedure.
- ▶ Have emergency equipment readily available. Keep resuscitation equipment on hand in case of respiratory impairment or laryngospasm after the procedure.
- ▶ Avoid using morphine sulfate in patients with asthma or other pulmonary disease. This drug can further exacerbate bronchospasms and respiratory impairment.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Assist the patient to a comfortable position and direct the patient to breathe normally during the beginning of the general anesthesia. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Observe standard precautions and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date and time of collection, and any medication the patient is taking that may interfere with test results (e.g., antibiotics). Collect the specimen in the appropriate sterile collection container.

Bronchoscopy:

- ▶ Record baseline vital signs.
- ▶ The patient is positioned in relation to the type of anesthesia being used. If local anesthesia is used, the patient is seated and the tongue and oropharynx are sprayed and swabbed with anesthetic before the bronchoscope is inserted. For general anesthesia, the patient is placed in a supine position with the neck hyperextended. After anesthesia, the patient is kept in supine or shifted to a side-lying position and the bronchoscope is inserted. After inspection, the samples are collected from suspicious sites by bronchial brush or biopsy forceps.

Expectorated Specimen:

- ▶ Ask the patient to sit upright, with assistance and support (e.g., with an overbed table) as needed.
- ▶ Ask the patient to take two or three deep breaths and cough deeply. Any sputum raised should be expectorated directly into a sterile sputum collection container.
- ▶ If the patient is unable to produce the desired amount of sputum, several strategies may be attempted. One approach is to have the patient drink two glasses of water, and then assume the position for postural drainage of the upper and middle lung segments. Effective coughing may be assisted by placing either the hands or a pillow over the diaphragmatic area and applying slight pressure.
- ▶ Another approach is to place a vaporizer or other humidifying device at the bedside. After sufficient exposure to adequate humidification, postural drainage of the upper and middle lung segments may be repeated before attempting to obtain the specimen.
- ▶ Other methods may include obtaining an order for an expectorant to be administered with additional water approximately 2 hr before attempting to obtain the specimen. Chest percussion and postural drainage of all lung segments may also be employed. If the patient is still unable to raise sputum, the use of an ultrasonic nebulizer ("induced sputum") may be necessary; this is usually done by a respiratory therapist.

Tracheal Suctioning:

- ▶ Obtain the necessary equipment, including a suction device, suction kit, and Lukens tube or in-line trap.
- ▶ Position the patient with head elevated as high as tolerated.
- ▶ Put on sterile gloves. Maintain the dominant hand as sterile and the nondominant hand as clean.
- ▶ Using the sterile hand, attach the suction catheter to the rubber tubing of the Lukens tube or in-line trap. Then attach the suction tubing to the male adapter of the trap with the clean hand. Lubricate the suction-catheter with sterile saline.

- ▶ Tell nonintubated patients to protrude the tongue and to take a deep breathe as the suction catheter is passed through the nostril. When the catheter enters the trachea, a reflex cough is stimulated; immediately advance the catheter into the trachea and apply suction. Maintain suction for approximately 10 sec, but never longer than 15 sec. Withdraw the catheter without applying suction. Separate the suction catheter and suction tubing from the trap, and place the rubber tubing over the male adapter to seal the unit.
- ▶ For intubated patients or patients with a tracheostomy, the previous procedure is followed except that the suction catheter is passed through the existing endotracheal or tracheostomy tube rather than through the nostril. The patient should be hyperoxygenated before and after the procedure in accordance with standard protocols for suctioning these patients.
- ▶ Generally, a series of three to five early morning sputum samples are collected in sterile containers.

General:

- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume preoperative diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- ▶ Inform the patient that he or she may experience some throat soreness and hoarseness. Instruct patient to treat throat discomfort with lozenges and warm gargles when the gag reflex returns.
- ▶ Monitor vital signs and compare with baseline values every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor

temperature every 4 hr for 24 hr. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.

- ▶ Emergency resuscitation equipment should be readily available if the vocal cords become spastic after intubation.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the patient for hemoptysis, difficulty breathing, cough, air hunger, excessive coughing, pain, or absent breathing sounds over the affected area. Report any symptoms to the HCP.
- ▶ Evaluate the patient for symptoms indicating the development of pneumothorax, such as dyspnea, tachypnea, anxiety, decreased breathing sounds, or restlessness. A chest x-ray may be ordered to check for the presence of this complication.
- ▶ Evaluate the patient for symptoms of empyema, such as fever, tachycardia, malaise, or elevated white blood cell count.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ **Nutritional considerations:** Malnutrition is commonly seen in patients with severe respiratory disease for numerous reasons including fatigue, lack of appetite, and gastrointestinal distress. Adequate intake of vitamins A and C are also important to prevent pulmonary infection and to decrease the extent of lung tissue damage.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient to use lozenges or

gargle for throat discomfort. Inform the patient of smoking cessation programs as appropriate. The importance of following the prescribed diet should be stressed to the patient/caregiver. Educate the patient regarding access to counseling services, as appropriate. Provide information regarding vaccine preventable diseases where indicated (e.g., diphtheria, influenza, measles, mumps, pertussis, rubella, smallpox, varicella). Answer any questions or address any concerns voiced by the patient or family.

- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies, anti-glomerular basement membrane, arterial/alveolar oxygen ratio, biopsy lung, blood gases, bronchoscopy, chest x-ray, complete blood count, CT thoracic, culture (fungal, mycobacterium, throat, viral), cytology sputum, gallium scan, gram stain/acid-fast stain, HIV-1/2 antibodies, lung perfusion scan, lung ventilation scan, MRI chest, mediastinoscopy, pleural fluid analysis, PFT, and TB tests.
- ▶ Refer to the Immune and Respiratory System tables at the end of the book for related tests by body system.

Culture, Bacterial, Stool

SYNONYM/ACRONYM: N/A.

SPECIMEN: Fresh random stool collected in a clean plastic container.

REFERENCE VALUE: (Method: Culture on selective media for identification of pathogens usually to include *Salmonella*, *Shigella*, *Escherichia coli* O157:H7, *Yersinia enterocolitica*, and *Campylobacter*; latex agglutination or enzyme immunoassay for *Clostridium* A and B toxins) Negative: No growth of pathogens. Normal fecal flora is 96% to 99% anaerobes and 1% to 4% aerobes. Normal flora present may include *Bacteroides*, *Candida albicans*, *Clostridium*, *Enterococcus*, *E. coli*, *Proteus*, *Pseudomonas*, and *Staphylococcus aureus*.

DESCRIPTION: Stool culture involves collecting a sample of feces so that organisms present can be isolated and identified. Certain bacteria are normally found in feces. However, when overgrowth of these organisms

occurs or pathological organisms are present, diarrhea or other signs and symptoms of systemic infection occur. These symptoms are the result of damage to the intestinal tissue by the pathogenic organisms.

Routine stool culture normally screens for a small number of common pathogens, such as *Campylobacter*, *Salmonella*, and *Shigella*. Identification of other bacteria is initiated by special request or upon consultation with a microbiologist when there is knowledge of special circumstances. The laboratory will initiate antibiotic sensitivity testing if indicated by test results. Sensitivity testing identifies the antibiotics to which organisms are susceptible to ensure an effective treatment plan. Life-threatening *Clostridium difficile* infection of the bowel may occur in patients who are immunocompromised or are receiving broad-spectrum antibiotic therapy (e.g., clindamycin, ampicillin, cephalosporins). The bacteria release a toxin that causes necrosis of the colon tissue. The toxin can be more rapidly identified from a stool sample using an immunochemical method than from a routine culture. Appropriate interventions can be quickly initiated and might include IV replacement of fluid and electrolytes, cessation of broad spectrum antibiotic administration, and institution of vancomycin or metronidazole antibiotic therapy.

INDICATIONS:

- Assist in establishing a diagnosis for diarrhea of unknown etiology
- Identify pathogenic organisms causing gastrointestinal disease and carrier states


RESULT:

Positive findings in:

- Bacterial infection: *Aeromonas* spp., *Bacillus cereus*, *Campylobacter*, *Clostridium*

difficile, *E. coli*, including serotype O157: H7, *Plesiomonas shigelloides*, *Salmonella*, *Shigella*, *Yersinia*, and *Vibrio*. Isolation of *Staphylococcus aureus* may indicate infection or a carrier state.

- Botulism: *Clostridium botulinum* (the bacteria must also be isolated from the food or the presence of toxin confirmed in the stool specimen).

CRITICAL VALUES:  Note and immediately report to the health care provider (HCP) positive results for bacterial pathogens *Campylobacter*, *Clostridium difficile*, *E. coli* 0157:H7, *Listeria*, *Rotavirus*, *Salmonella*, *Shigella*, *Vibrio*, *Yersinia*, or parasites *Acanthamoeba*, *Cyclospora*, *Cryptosporidium*, *Entamoeba histolytica*, *Giardia*, parasitic ova, proglottid and larvae.

INTERFERING FACTORS:

- A rectal swab does not provide an adequate amount of specimen for evaluating the carrier state and should be avoided in favor of a standard stool specimen.
- A rectal swab should never be submitted for *Clostridium* toxin studies. Specimens for *Clostridium* toxins should be refrigerated if they are not immediately transported to the laboratory as toxins degrade rapidly.
- A rectal swab should never be submitted for *Campylobacter* culture. Excessive exposure of the sample to air or room temperature may damage this bacterium so that it will not grow in the culture.
- Therapy with antibiotics before specimen collection may decrease the type and the amount of bacteria.
- Failure to transport the culture within 1 hr of collection or urine contamination of the sample may affect results.
- Barium and laxatives used less than 1 wk before the test may reduce bacterial growth.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify pathogenic bacterial organisms.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's gastrointestinal and immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a history of the patient's travel to foreign countries.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent medications that can interfere with test results.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be some discomfort during the specimen collection. Inform the patient that specimen collection takes approximately 5 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions prior to the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and any

medication the patient is taking that may interfere with test results (e.g., antibiotics).

- ▶ Collect a stool specimen directly into a clean container. If the patient requires a bedpan, make sure it is clean and dry, and use a tongue blade to transfer the specimen to the container. Make sure representative portions of the stool are sent for analysis. Note specimen appearance on collection container label.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medication as directed by the HCP.
- ▶ Instruct the patient to report symptoms such as pain related to tissue inflammation or irritation.
- ▶ Advise the patient that final test results may take up to 72 hr but that antibiotic therapy may be started immediately. Instruct the patient about the importance of completing the entire course of antibiotic therapy even if no symptoms are present. Note: Antibiotic therapy is frequently contraindicated for *Salmonella* infection unless the infection has progressed to a systemic state.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Emphasize the importance of reporting continued signs and symptoms of the infection. Provide information regarding vaccine-preventable diseases where indicated (e.g., cholera, hepatitis A and B, human papillomavirus, typhoid, yellow fever). Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include capsule endoscopy, colonoscopy, fecal analysis, ova and parasites, and proctosigmoidoscopy.
- ▶ Refer to the Gastrointestinal and Immune System tables at the end of the book for related tests by body system.

Culture, Bacterial, Throat or Nasopharyngeal

SYNONYM/ACRONYM: Routine throat culture.

SPECIMEN: Throat or nasopharyngeal swab.

REFERENCE VALUE: (Method: Aerobic culture) No growth.

DESCRIPTION: The routine throat culture is a commonly ordered test to screen for the presence of group A β -hemolytic streptococci. *Streptococcus pyogenes* is the organism that most commonly causes acute pharyngitis. The more dangerous sequelae of scarlet fever, rheumatic heart disease, and glomerulonephritis are less frequently seen because of the early treatment of infection at the pharyngitis stage. There are a number of other bacterial agents responsible for pharyngitis. Specific cultures can be set up to detect other pathogens such as *Bordetella*, *Corynebacteria*, *Haemophilus*, or *Neisseria* if they are suspected or by special request from the health care provider (HCP). *Corynebacterium diphtheriae* is the causative agent of diphtheria. *Neisseria gonorrhoeae* is a sexually transmitted pathogen. In children, a positive throat culture for *Neisseria* usually indicates sexual

abuse. The laboratory will initiate antibiotic sensitivity testing if indicated by test results. Sensitivity testing identifies the antibiotics to which the organisms are susceptible to ensure an effective treatment plan.

INDICATIONS:

- Assist in the diagnosis of bacterial infections such as tonsillitis, diphtheria, gonorrhea, or pertussis
- Assist in the diagnosis of upper respiratory infections resulting in bronchitis, pharyngitis, croup, and influenza
- Isolate and identify group A β -hemolytic streptococci as the cause of strep throat, acute glomerulonephritis, scarlet fever, or rheumatic fever

RESULT: Reports on cultures that are positive for group A β -hemolytic streptococci are generally available within 24 to 48 hr. Cultures that report on normal respiratory flora are

issued after 48 hr. Culture results of no growth for *Corynebacterium* require 72 hr to report; 48 hr are required to report negative *Neisseria* cultures.

CRITICAL VALUES:

- Culture: Growth of corynebacterium or methicillin resistant staphylococcus aureus (MRSA)

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

- Contamination with oral flora may invalidate results.
- Specimen collection after antibiotic therapy has been initiated may result in inhibited or no growth of organisms.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify pathogenic bacterial organisms.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent medications that can interfere with test results.
- ▶ Review the procedure with the patient. In cases of acute epiglottitis, do not swab the throat! This can cause a laryngospasm resulting in a loss of airway. A patient with epiglottitis will be sitting up and leaning forward in the tripod position with the head and

jaw thrust forward to breathe. Address concerns about pain and explain that there may be some discomfort during the specimen collection. The time it takes to collect a proper specimen varies according to the level of cooperation of the patient. Inform the patient that specimen collection takes approximately 5 min.

- ▶ There are no food or fluid restrictions, unless by medical direction.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions prior to the procedure.
- ▶ Have emergency equipment readily available. Keep resuscitation equipment on hand in case of respiratory impairment or laryngospasm after the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and any medication the patient is taking that may interfere with test results (e.g., antibiotics).
- ▶ To collect the throat culture, tilt the patient's head back. Swab both tonsillar pillars and oropharynx with the sterile Culturette. A tongue depressor can be used to ensure that contact with the tongue and uvula is avoided.
- ▶ A nasopharyngeal specimen is collected through the use of a flexible probe inserted through the nose and directed toward the back of the throat.
- ▶ Place the swab in the Culturette tube and squeeze the bottom of the Culturette tube to release the liquid transport medium. Ensure that the end of the swab is immersed in the liquid transport medium.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medication as directed by the HCP.
- ▶ Instruct the patient to notify the HCP immediately if difficulty in breathing or swallowing occurs or if bleeding occurs.
- ▶ Instruct the patient to perform mouth care after the specimen has been obtained.
- ▶ Provide comfort measures and treatment such as antiseptic gargles, inhalants, and warm, moist applications as needed. A cool beverage may aid in relieving throat irritation caused by coughing or suctioning.
- ▶ Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ **Nutritional considerations:** Dehydration can be seen in patients with a bacterial throat infection due to pain with swallowing. Pain medications reduce patient's dysphagia and allow for adequate intake of fluids and foods.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's

lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient to use lozenges or gargle for throat discomfort. Inform the patient of smoking cessation programs as appropriate. Emphasize the importance of reporting continued signs and symptoms of the infection. Provide information regarding vaccine-preventable diseases where indicated (e.g., diphtheria, hepatitis B, HPV, influenza, measles, mumps, pertussis, pneumococcal, rubella). Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count and group A streptococcal screen.
- ▶ Refer to the Immune and Respiratory System tables at the end of the book for related tests by body system.

Culture, Bacterial, Urine

SYNONYM/ACRONYM: Routine urine culture.

SPECIMEN: Urine (5 mL) collected in a sterile plastic collection container.

REFERENCE VALUE: (Method: Culture on selective and enriched media) Negative: no growth.

DESCRIPTION: A urine culture involves collecting a urine specimen so that the organism causing disease can be isolated and

identified. Urine can be collected by clean catch, urinary catheterization, or suprapubic aspiration. The severity of the

infection or contamination of the specimen can be determined by knowing the type and number of organisms (colonies) present in the specimen. The laboratory will initiate sensitivity testing if indicated by test results. Sensitivity testing identifies the antibiotics to which the organisms are susceptible to ensure an effective treatment plan.

Commonly detected organisms are those normally found in the genitourinary tract, including enterococci, *Escherichia coli*, *Klebsiella*, *Proteus*, and *Pseudomonas*. A culture showing multiple organisms indicates a contaminated specimen.

Colony counts of 100,000/mL or more indicate urinary tract infection (UTI).

Colony counts of 1000/mL or less suggest contamination resulting from poor collection technique.

Colony counts between 1000 and 10,000/mL may be significant depending on a variety of factors, including patient's age, gender, number of types of organisms present, method of specimen collection, and presence of antibiotics.

INDICATIONS:

- Assist in the diagnosis of suspected UTI
- Determine the sensitivity of significant organisms to antibiotics
- Monitor the response to UTI treatment

RESULT:

Positive findings in:

- UTIs

Negative findings in: N/A

CRITICAL VALUES:

- Extended spectrum beta lactamases (ESBL) *E coli* or *Klebsiella*
- *Legionella*
- Vancomycin resistant *Enterococci* (VRE)
- Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

- Antibiotic therapy initiated before specimen collection may produce false-negative results.
- Improper collection techniques may result in specimen contamination.
- Specimen storage for longer than 30 min at room temperature or 24 hr at refrigerated temperature may result in overgrowth of bacteria and false-positive results.
- Results of urine culture are often interpreted along with routine urinalysis findings.
- Discrepancies between culture and urinalysis may be reason to re-collect the specimen.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to identify pathogenic bacterial organisms.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens.
- ◆ Obtain a history of the patient's genitourinary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Note any recent medications that can interfere with test results.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be some discomfort during the specimen collection. Inform the patient that specimen collection depends on patient cooperation and usually takes approximately 5 to 10 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction.
- ▶ Instruct the patient on clean-catch procedure and provide necessary supplies.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions prior to the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, method of specimen collection, and any medications the patient has taken that may interfere with test results (e.g., antibiotics).

Clean-Catch Specimen:

- ▶ Instruct the male patient to
 - (1) thoroughly wash his hands,
 - (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to
 - (1) thoroughly wash her hands;
 - (2) cleanse the labia from front to back;
 - (3) while keeping the labia separated, void a small amount into the toilet; and
 - (4) without interrupting the urine stream, void directly into the specimen container.

Pediatric Urine Collector:

- ▶ Put on gloves. Appropriately cleanse the genital area, and allow the area to dry. Remove the covering over the

adhesive strips on the collector bag and apply over the genital area. Diaper the child. When specimen is obtained, place the entire collection bag in a sterile urine container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Urinary Catheterization:

- ▶ Place female patient in lithotomy position or male patient in supine position. Using sterile technique, open the straight urinary catheterization kit and perform urinary catheterization. Place the retained urine in a sterile specimen container.

Suprapubic Aspiration:

- ▶ Place the patient in supine position. Cleanse the area with antiseptic, and drape with sterile drapes. A needle is inserted through the skin into the bladder. A syringe attached to the needle is used to aspirate the urine sample. The needle is then removed and a sterile dressing is applied to the site. Place the sterile sample in a sterile specimen container.
- ▶ Do not collect urine from the pouch from a patient with a urinary diversion (e.g., ileal conduit). Instead, perform catheterization through the stoma.

General:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis. If a delay in transport is expected, add an equal volume of 50% alcohol to the specimen as a preservative.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medication as directed by the HCP.
- ▶ Instruct the patient to report symptoms such as pain related to tissue inflammation, pain or irritation during void,

bladder spasms, or alterations in urinary elimination.

- ▶ Observe for signs of inflammation if the specimen is obtained by suprapubic aspiration.
- ▶ Administer antibiotic therapy as ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ **Nutritional considerations:** Instruct the patient to increase water consumption by drinking 8 to 12 glasses of water to assist in flushing the urinary tract. Instruct the patient to avoid alcohol, caffeine, and carbonated beverages, which can cause bladder irritation.
- ▶ Prevention of UTIs includes increasing daily water consumption, urinating when urge occurs, wiping the perineal area from front to back after urination/defecation, and urinating immediately after intercourse. Prevention also includes maintaining the normal flora of the body. Patients should avoid using spermicidal creams with diaphragms or condoms (when recommended by a HCP), becoming constipated, douching, taking bubble baths, wearing tight-fitting garments, and using deodorizing feminine hygiene products that alter the body's normal flora and increase susceptibility to UTIs.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Emphasize the importance of reporting continued signs and symptoms of the infection. Instruct patient on the proper technique for wiping the perineal area (front to back) after a bowel movement. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count, complete blood count, WBC count and differential, cystometry, cystoscopy, cystourethrography voiding, cytology urine, gram stain, renogram, and UA.
- ▶ Refer to the Genitourinary and Immune System tables at the end of the book for related tests by body system.

Culture, Fungal

SYNONYM/ACRONYM: N/A.

SPECIMEN: Hair, skin, nail, pus, sterile fluids, blood, bone marrow, stool, bronchial washings, sputum, or tissue samples collected in a sterile plastic, tightly capped container.

REFERENCE VALUE: (Method: Culture on selective media; macroscopic and microscopic examination) No presence of fungi.

DESCRIPTION: Fungi, organisms that normally live in soil, can be introduced into humans through the accidental inhalation of spores or inoculation of spores into tissue through trauma. Individuals most susceptible to fungal infection usually are debilitated by chronic disease, are receiving prolonged antibiotic therapy, or have impaired immune systems. Fungal diseases may be classified according to the involved tissue type: dermatophytoses involve superficial and cutaneous tissue; there are also subcutaneous and systemic mycoses.

INDICATIONS:

- Determine antimicrobial sensitivity of the organism
- Isolate and identify organisms responsible for nail infections or abnormalities
- Isolate and identify organisms responsible for skin eruptions, drainage, or other evidence of infection

RESULT:

Positive findings in:

- Blood
 - Candida albicans*
 - Histoplasma capsulatum*
- Cerebrospinal fluid
 - Coccidioides immitis*
 - Cryptococcus neoformans*
 - Members of the order Mucorales
 - Paracoccidioides brasiliensis*
 - Sporothrix schenckii*
- Hair
 - Epidermophyton*
 - Microsporum*
 - Trichophyton*
- Nails
 - Candida albicans*
 - Cephalosporium*

Epidermophyton
Trichophyton

- Skin
 - Actinomyces israelii*
 - Candida albicans*
 - Coccidioides immitis*
 - Epidermophyton*
 - Microsporum*
 - Trichophyton*
- Tissue
 - A. israelii*
 - Aspergillus*
 - Candida albicans*
 - Nocardia*
 - Paracoccidioides brasiliensis*

CRITICAL VALUES: N/A.

INTERFERING FACTORS:

Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to identify pathogenic fungal organisms.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens.
- ♦ Obtain a history of the patient's immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Note any recent medications that can interfere with test results.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 min.

Address concerns about pain and explain that there may be some discomfort during the specimen collection.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Instructions regarding the appropriate transport materials for blood, bone marrow, bronchial washings, sputum, sterile fluids, stool, and tissue samples should be obtained from the laboratory. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date, and time of collection.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

Skin:

- ▶ Clean the collection site with 70% alcohol. Scrape the peripheral margin of the collection site with a sterile scalpel or wooden spatula. Place the scrapings in a sterile collection container.

Hair:

- ▶ Fungi usually grow at the base of the hair shaft. Infected hairs can be identified by using a Wood's lamp in a darkened room. A Wood's lamp provides rays of ultraviolet light at a wavelength of 366 nm, or 3660 Å. Infected hairs fluoresce a bright yellow-green when exposed to light from the Wood's lamp. Using tweezers, pluck hair from skin.

Nails:

- ▶ Ideally, softened material from the nail bed is sampled from beneath the nail plate. Alternatively, shavings from the deeper portions of the nail itself can be collected.

- ▶ The potassium hydroxide (KOH) test is used to indicate the presence of mycelium, mycelial fragments, spores, or budding yeast cells. A portion of the specimen is mixed with 15% KOH on a glass slide, and then the slide is covered and gently heated briefly. The slide is examined under a microscope for the presence of fungal elements.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct patient to begin antifungal therapy, as prescribed. Instruct the patient in the importance of completing the entire course of antifungal therapy even if no symptoms are present.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Emphasize the importance of reporting continued signs and symptoms of the infection. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include relevant biopsies (lung, lymph node, skin), bronchoscopy, cultures (blood, mycobacteria, throat, sputum, viral), CSF analysis, gallium scan, HIV-1/2 antibodies, pulmonary function tests, and TB tests.
- ▶ Refer to the Immune System table at the back of the book for related tests by body system.

Culture, Viral

SYNONYM/ACRONYM: N/A.

SPECIMEN: Urine, semen, blood, body fluid, stool, tissue, or swabs from the affected site.

REFERENCE VALUE: (Method: Culture in special media, enzyme-linked immunoassays, direct fluorescent antibody techniques, latex agglutination, immunoperoxidase techniques) No virus isolated.

DESCRIPTION: Viruses, the most common cause of human infection, are submicroscopic organisms that invade living cells. They can be classified as either RNA- or DNA-type viruses. Viral titers are highest in the early stages of disease before the host has begun to manufacture significant antibodies against the invader. Specimens need to be collected as early in the disease process as possible.

INDICATIONS:

Assist in the identification of viral infection

RESULT:

Positive findings in:

- Acquired immunodeficiency syndrome
Human immunodeficiency virus (HIV)
- Acute respiratory failure
Hantavirus
- Anorectal infections
Herpes simplex virus (HSV)
Human papillomavirus (HPV)
- Bronchitis
Parainfluenza virus
Respiratory syncytial virus (RSV)
- Cervical cancer
Human papillomavirus

- Condylomata
Human papillomavirus
- Conjunctivitis/keratitis
Adenovirus
Epstein-Barr virus
HSV
Measles virus
Parvovirus
Rubella virus
Varicella-zoster virus
- Croup
Parainfluenza virus
RSV
- Cutaneous infection with rash
Enteroviruses
HSV
Varicella-zoster virus
- Encephalitis
Enteroviruses
Flaviviruses
HSV
HIV
Measles virus
Rabies virus
Togaviruses
- Febrile illness with rash
Coxsackieviruses
Echovirus
- Gastroenteritis
Norwalk virus
Rotavirus
- Genital herpes
HSV-1
HSV-2

- Genital warts
HPV
- Hemorrhagic cystitis
Adenovirus
- Hemorrhagic fever
Ebola virus
Hantavirus
Lassa virus
Marburg virus
- Herpangina
Coxsackievirus (group A)
- Infectious mononucleosis
Cytomegalovirus
Epstein-Barr virus
- Meningitis
Coxsackieviruses
Echovirus
HSV-2
Lymphocytic choriomeningitis virus
- Myocarditis/pericarditis
Coxsackievirus
Echovirus
- Parotitis
Mumps virus
Parainfluenza virus
- Pharyngitis
Adenovirus
Coxsackievirus (group A)
Epstein-Barr virus
HSV
Influenza virus
Parainfluenza virus
Rhinovirus
- Pleurodynia
Coxsackievirus (group B)
- Pneumonia
Adenovirus
Influenza virus
Parainfluenza virus
RSV
- Upper respiratory tract infection
Adenovirus
Coronavirus
Influenza virus
Parainfluenza virus
RSV
Rhinovirus

CRITICAL VALUES:

Positive RSV, influenza, and varicella zoster cultures should be reported immediately to the requesting health care provider (HCP).

INTERFERING FACTORS:

Viral specimens are unstable. Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify pathogenic viral organisms.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal, genitourinary, immune, reproductive, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent medications that can interfere with test results.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 min. Address concerns about pain and explain that there may be some discomfort during the specimen collection.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, exact site, contact person for notification of results, and other pertinent information (e.g., patient immunocompromised owing to organ transplant, radiation, or chemotherapy).
- ▶ Instructions regarding the appropriate transport materials for blood, bronchial washings, sputum, sterile fluids, stool, and tissue samples should be obtained from the laboratory. The type of applicator used to obtain swabs should be verified by consultation with the testing laboratory personnel.
- ▶ The appropriate viral transport material should be obtained from the laboratory. Nasopharyngeal washings or swabs for RSV testing should be immediately placed in cold viral transport media.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Dehydration can be seen in patients with viral infections due to loss of fluids through fever, diarrhea, and/or vomiting. Antipyretic medication includes acetaminophen to decrease fever and allow for adequate intake of fluids and foods. Do not give acetylsalicylic acid to patients with a viral illness as there is an increased risk of Reye's syndrome.
- ▶ **Sensitivity to social and cultural issues:** Offer support, as appropriate, to patients who may be the victims of rape or sexual assault. Educate the patient regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for

- discussing the risks of sexually transmitted diseases. It is also important to address problems the patient may experience (e.g., guilt, depression, anger).
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Provide information regarding vaccine-preventable diseases where indicated (e.g., encephalitis, hepatitis A and B, HPV, influenza, measles, mumps, polio, rubella, smallpox, varicella, yellow fever). Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include relevant alveolar/arterial gradient, β -2-microglobulin, barium enema, biopsy (cervical, intestinal, kidney, liver, lung, lymph node, muscle, skin), blood gases, bronchoscopy, CD4/CD8 ratio, CSF analysis, chlamydia group antibody, chest x-ray, cultures (anal, blood, ear, eye, fungal, genital, mycobacteria, skin, sputum, stool, throat, urine, wound), cytology (sputum, urine), gallium scan, gastric emptying scan, lung perfusion scan, lung ventilation scan, PAP smear, pericardial fluid analysis, plethysmography, pulse oximetry, PFT, slit-lamp biomicroscopy, syphilis serology, TB tests, and viral serology tests (hepatitis, HIV, HTLV, infectious mono, mumps, rubella, rubeola, varicella).
- ▶ Refer to the Gastrointestinal, Genitourinary, Immune, Reproductive, and Respiratory System tables at the end of the book for related tests by body system.

Cystometry

SYNONYM/ACRONYM: Urodynamic testing of bladder function, CMG.

AREA OF APPLICATION: Bladder, urethra.

CONTRAST: None.

DESCRIPTION: Cystometry evaluates the motor and sensory function of the bladder when incontinence is present or neurological bladder dysfunction is suspected, and monitors the effects of treatment for the abnormalities. This noninvasive manometric study measures the bladder pressure and volume characteristics in milliliters of water (cm H₂O) during the filling and emptying phases. The test provides information about bladder structure and function that can lead to uninhibited bladder contractions, sensations of bladder fullness and need to void, and ability to inhibit voiding. These abnormalities cause incontinence and other impaired patterns of micturition. Cystometry can be performed with cystoscopy and sphincter electromyography.

INDICATIONS:

- Detect congenital urinary abnormalities
- Determine cause of bladder dysfunction and pathology
- Determine cause of recurrent urinary tract infections (UTIs)
- Determine cause of urinary retention
- Determine type of incontinence: *functional* (involuntary and

unpredictable), *reflex* (involuntary when a specific volume is reached), *stress* (weak pelvic muscles), *total* (continuous and unpredictable), *urge* (involuntary when urgency is sensed), and *psychological* (e.g., dementia, confusion affecting awareness)

- Determine type of neurogenic bladder (motor or sensory)
- Evaluate the management of neurological bladder before surgical intervention
- Evaluate postprostatectomy incontinence
- Evaluate signs and symptoms of urinary elimination pattern dysfunction
- Evaluate urinary obstruction in male patients experiencing urinary retention
- Evaluate the usefulness of drug therapy on detrusor muscle function and tonicity and on internal and external sphincter function
- Evaluate voiding disorders associated with spinal cord injury

RESULT:

Normal findings in:

- Absence of residual urine (0 mL)
- Normal sensory perception of bladder fullness, desire to void, and ability to inhibit urination; appropriate response to temperature (hot and cold)
- Normal bladder capacity: 350 to 750 mL for men and 250 to 550 mL for women

- Normal functioning bladder pressure: 8 to 15 cm H₂O
- Normal sensation of fullness: 40 to 100 cm H₂O or 300 to 500 mL
- Normal bladder pressure during voiding: 30 to 40 cm H₂O
- Normal detrusor pressure: less than 10 cm H₂O
- Normal urge to void: 150 to 450 mL
- Normal filling pattern
- Urethral pressure that is higher than bladder pressure, ensuring continence

Abnormal findings in:

- Flaccid bladder that fills without contracting
- Inability to perceive bladder fullness
- Inability to initiate or maintain urination without applying external pressure
- Sensory or motor paralysis of bladder
- Total loss of conscious sensation and vesical control or uncontrollable micturition (incontinence)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with acute UTIs because the study can cause infection to spread to the kidneys
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Patients with urethral obstruction
- Patients with cervical cord lesions because they may exhibit autonomic dysreflexia, as seen by bradycardia, flushing, hypertension, diaphoresis, and headache
- Inability to catheterize the patient

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the

- procedure because of age, significant pain, or mental status
- Inability of the patient to void in a supine position or straining to void during the study
- A high level of patient anxiety or embarrassment, which may interfere with the study, making it difficult to distinguish whether the results are due to stress or organic pathology
- Administration of drugs that affect bladder function, such as muscle relaxants or antihistamines

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses bladder function.
- ▶ Obtain a history of the patient's complaints including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, and dyes.
- ▶ Obtain a history of the patient's genitourinary and renal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Assess hematological status, blood-clotting ability, and urinalysis findings for abnormalities.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced

during the test. Inform the patient that the procedure is performed in a special urology room or in a clinic setting by the health care provider (HCP), with support staff, and takes approximately 30 to 45 min.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to report pain, sweating, nausea, headache, and the urge to void during the study.
- ▶ Instruct the patient to remove jewelry and other metallic objects in the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to change into the gown, robe, and foot coverings provided, but not to void.
- ▶ Position the patient in a supine or lithotomy position on the examining table. If spinal cord injury is present, the patient can remain on a stretcher in a supine position and be draped appropriately.
- ▶ Ask the patient to void. During voiding, note characteristics such as start time; force and continuity of the stream; volume voided; presence of dribbling, straining, or hesitancy; and stop time.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still during the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ A urinary catheter is inserted into the bladder under sterile conditions, and residual urine is measured and recorded. A test for sensory response to temperature is done by instilling 30 mL of room-temperature sterile water followed by 30 mL of warm

sterile water. Sensations are assessed and recorded.

- ▶ Fluid is removed from the bladder, and the catheter is connected to a cystometer that measures the pressure. Sterile normal saline, distilled water, or carbon dioxide gas is instilled in controlled amounts into the bladder. When the client indicates the urge to void, the bladder is considered full. The patient is instructed to void, and urination amounts as well as start and stop times are then recorded.
- ▶ Pressure and volume readings are recorded and graphed for response to heat, full bladder, urge to void, and ability to inhibit voiding. The patient is requested to void without straining, and pressures are taken and recorded during this activity.
- ▶ After completion of voiding, the bladder is emptied of any other fluid, and the catheter is withdrawn, unless further testing is planned.
- ▶ Further testing may be done to determine if abnormal bladder function is being caused by muscle incompetence or interruption in innervation; anticholinergic medication (e.g., atropine) or cholinergic medication (e.g., bethanechol [Urecholine]) can be injected and the study repeated in 20 or 30 min.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Monitor fluid intake and urinary output for 24 hr after the procedure.
- ▶ Monitor vital signs after the procedure every 15 min for 2 hr or as directed. Elevated temperature may indicate infection. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Inform the patient that he or she may experience burning or discomfort on urination for a few voidings after the procedure.
- ▶ Emphasize that persistent flank or suprapubic pain, fever, chills, blood in the urine, difficulty urinating, or change in urinary pattern must be reported immediately to the HCP.
- ▶ Recognize anxiety related to test results. Discuss the implications of

abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and

determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include bladder cancer markers, calculus kidney stone panel, chlamydia group antibody, CT pelvis, culture urine, cytology urine, IVP, MRI pelvis, UA, and US pelvis.
- ▶ Refer to the Genitourinary and Renal System tables in the back of the book for related tests by body system.

Cystoscopy

SYNONYM/ACRONYM: Cystoureterography, cystourethrography, prostatography.

AREA OF APPLICATION: Bladder, urethra, ureteral orifices.

CONTRAST: None.

DESCRIPTION: Cystoscopy provides direct visualization of the urethra, urinary bladder, and ureteral orifices—areas not usually visible with x-ray procedures. This procedure is also used to obtain specimens and treat pathology associated with the aforementioned structures. Cystoscopy is accomplished by transurethral insertion of a cystoscope into the bladder. Rigid cystoscopes contain an obturator and a telescope with a lens and light system; there are also flexible cystoscopes, which use fiberoptic technology. The procedure may be performed during or after ultrasonography or radiography, or during urethroscopy or retrograde pyelography.

INDICATIONS:

- Coagulate bleeding areas
- Determine the possible source of persistent urinary tract infections
- Determine the source of hematuria of unknown cause
- Differentiate, through tissue biopsy, between benign and cancerous lesions involving the bladder
- Dilate the urethra and ureters
- Evacuate blood clots and perform fulguration of bleeding sites within the lower urinary tract
- Evaluate changes in urinary elimination patterns
- Evaluate the extent of prostatic hyperplasia and degree of obstruction
- Evaluate the function of each kidney by obtaining urine samples via ureteral catheters

- Evaluate urinary tract abnormalities such as dysuria, frequency, retention, inadequate stream, urgency, and incontinence
- Identify and remove polyps and small tumors (including by fulguration) from the bladder
- Identify congenital anomalies, such as duplicate ureters, ureteroceles, urethral or ureteral strictures, diverticula, and areas of inflammation or ulceration
- Implant radioactive seeds
- Place ureteral catheters to drain urine from the renal pelvis or for retrograde pyelography
- Place ureteral stents and resect prostate gland tissue (transurethral resection of the prostate)
- Remove renal calculi from the bladder or ureters
- Resect small tumors
- Patients with bleeding disorders because instrumentation may lead to excessive bleeding from the lower urinary tract
- Patients with acute cystitis or urethritis because instrumentation could allow bacteria to enter the bloodstream, resulting in septicemia

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

RESULT:

Normal findings in:

- Normal ureter, bladder, and urethral structure

Abnormal findings in:

- Diverticulum of the bladder, fistula, stones, and strictures
- Inflammation or infection
- Obstruction
- Polyps
- Prostatic hypertrophy or hyperplasia
- Renal calculi
- Tumors
- Ureteral or urethral stricture
- Urinary tract malformation and congenital anomalies

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the urinary tract.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, and dyes.
- ▶ Obtain a history of results of the patient's genitourinary system, symptoms, and previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.

Note the last time and dose of medication taken.

- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in a special cystoscopy suite near or in the surgery department by a health care provider (HCP), with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Restrict food and fluids for 8 hr if the patient is having general or spinal anesthesia. For local anesthesia, allow only clear liquids 8 hr before the procedure. Protocols may vary from facility to facility.
- ▶ Obtain and record the patient's vital signs.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 8 hr depending on the anesthetic chosen for the procedure.
- ▶ Administer ordered preoperative sedation.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
- ▶ Position patient on the examination table draped and with legs in stirrups. If general or spinal anesthesia is to be used, it is administered before positioning the patient on the table.
- ▶ Cleanse external genitalia with antiseptic solution. If local anesthetic is used, it is instilled into the urethra and retained for 5 to 10 min. A penile

clamp may be used for male patients to aid in retention of anesthetic.

- ▶ The HCP inserts a cystoscope or a urethroscope to examine the urethra before cystoscopy. The urethroscope has a sheath that may be left in place, and the cystoscope is inserted through it, avoiding multiple instrumentations.
- ▶ After insertion of the cystoscope, a sample of residual urine may be obtained for culture or other analysis.
- ▶ The bladder is irrigated via an irrigation system attached to the scope. The irrigation fluid aids in bladder visualization.
- ▶ If a prostatic tumor is found, a biopsy specimen may be obtained by means of a cytology brush or biopsy forceps inserted through the scope. If the tumor is small and localized, it can be excised and fulgurated. This procedure is termed *transurethral resection of the bladder*. Polyps can also be identified and excised.
- ▶ Ulcers or bleeding sites can be fulgurated using electrocautery.
- ▶ Renal calculi can be crushed and removed from the ureters and bladder.
- ▶ Ureteral catheters can be inserted via the scope to obtain urine samples from each kidney for comparative analysis and radiographic studies.
- ▶ Ureteral and urethral strictures can also be dilated during this procedure.
- ▶ Upon completion of the examination and related procedures, the cystoscope is withdrawn.
- ▶ Place obtained specimens in proper containers, label them properly, and immediately transport them to the laboratory.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume his or her usual diet and medications, as directed by the HCP.
- ▶ Encourage the patient to drink increased amounts of fluids (125 mL/hr for 24 hr) after the procedure.
- ▶ Monitor vital signs and neurologic status every 15 min for 1 hr, then every

2 hr for 4 hr, and then as ordered by the HCP. Take the temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.

- ◆ Monitor fluid intake and urinary output for 24 hr after the procedure. Decreased urine output may indicate bladder edema or perforation caused by forceful advancement of instrumentation.
- ◆ Inform the patient that burning or discomfort on urination can be experienced for a few voidings after the procedure and that the urine may be blood-tinged for the first and second voidings after the procedure.
- ◆ Emphasize that persistent flank or suprapubic pain, fever, chills, blood in the urine, difficulty urinating, or change in urinary pattern must be reported immediately to the HCP.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and

information regarding the clinical implications of the test results, as appropriate.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include biopsy kidney, biopsy prostate, calculus kidney stone panel, chlamydia group antibody, CT pelvis, culture urine, cytology urine, IVP, MRI pelvis, PSA, US pelvis, and UA.
- ◆ Refer to the Genitourinary System table in the back of the book for related tests by body system.

Cystourethrography, Voiding

SYNONYM/ACRONYM: Voiding cystography (VCU).

AREA OF APPLICATION: Bladder, urethra.

CONTRAST: Radiopaque iodine-based contrast medium.

DESCRIPTION: Voiding cystourethrography involves visualization of the bladder filled with contrast medium instilled through a catheter by use of a syringe or gravity, and, after the catheter is removed, the excretion of the contrast medium. Excretion or micturition is recorded electronically or

on videotape for confirmation or exclusion of ureteral reflux and evaluation of the urethra. Fluoroscopic or plain images may also be taken to record bladder filling and emptying. This procedure is often used to evaluate chronic urinary tract infections (UTIs).

INDICATIONS:

- Assess the degree of compromise of a stenotic prostatic urethra
- Assess hypertrophy of the prostate lobes
- Assess ureteral stricture
- Confirm the diagnosis of congenital lower urinary tract anomaly
- Evaluate abnormal bladder emptying and incontinence
- Evaluate the effects of bladder trauma
- Evaluate possible cause of frequent UTIs
- Evaluate the presence and extent of ureteral reflux
- Evaluate the urethra for obstruction and strictures


RESULT:**Normal findings in:**



- Normal bladder and urethra structure and function

Abnormal findings in:

- Bladder trauma
- Bladder tumors
- Hematomas
- Neurogenic bladder
- Pelvic tumors
- Prostatic enlargement
- Ureteral stricture
- Ureterocele
- Urethral diverticula
- Vesicoureteral reflux

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.

- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
- Patients with UTI, obstruction, or injury.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.

Factors that may impair clear imaging:

- Metallic objects within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the examination room with the patient should wear a protective lead apron, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

**NURSING IMPLICATIONS
AND PROCEDURE****PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the urinary tract.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, and dyes.
- ▶ Obtain a history of results of the patient's genitourinary system, symptoms, and previously performed laboratory tests and diagnostic and surgical procedures. Ensure that the results of blood tests are obtained and recorded before the procedure, especially coagulation tests, BUN and creatinine, if contrast medium is to be used.
- ▶ Ensure that this procedure is performed before an upper gastrointestinal study or barium swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in the radiology department by a HCP, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is

important in providing psychological support before, during, and after the procedure.

- ▶ Inform the patient that he or she may receive a laxative the night before the test or an enema or a cathartic the morning of the test, as ordered.
- ▶ Instruct the patient to increase fluid intake the day before the test, and to have only clear fluids 8 hr before the test.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions. Assess for completion of bowel preparation if ordered.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Instruct the patient to cooperate fully and to follow directions.
- ▶ Insert a Foley catheter before the procedure, if ordered. Inform the patient that he or she may feel some pressure when the catheter is inserted and when the contrast medium is instilled through the catheter.
- ▶ Place the patient on the table in a supine or lithotomy position.
- ▶ A kidney, ureter, and bladder film or plain radiograph is taken to ensure that no barium or stool obscures visualization of the urinary system.
- ▶ A catheter is filled with contrast medium to eliminate air pockets and is inserted until the balloon reaches the meatus if not previously inserted in the patient.

- When three-fourths of the contrast medium has been injected, a radiographic exposure is made while the remainder of the contrast medium is injected.
- When the patient is able to void, the catheter is removed and the patient is asked to urinate while images of the bladder and urethra are recorded.
- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

POST-TEST:

- A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume usual diet and medications, as directed by the HCP.
- Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- Monitor for reaction to iodinated contrast medium, including rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- Maintain the patient on adequate hydration after the procedure. Encourage the patient to drink increased amounts of fluids (125 mL/hr for 24 hr) after the procedure

to prevent stasis and bacterial buildup.

- Monitor fluid intake and urinary output for 24 hr after the procedure. Decreased urinary output may indicate impending renal failure or edema caused by instrumentation.
- Monitor for signs of sepsis: fever, chills, and severe pelvic pain.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include biopsy prostate, bladder cancer markers, BUN, CT pelvis, creatinine cytology urine, IVP, MRI pelvis, PSA, PT/INR and US pelvis.
- Refer to the Genitourinary System table at the back of the book for related tests by body system.

Cytology, Sputum

SYNONYM/ACRONYM: N/A.

SPECIMEN: Sputum (10 to 15 mL) collected on three to five consecutive first-morning, deep-cough expectorations.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination) Negative for abnormal cells, fungi, ova, and parasites.

DESCRIPTION: Cytology is the study of the origin, structure, function, and pathology of cells. In clinical practice, cytological examinations are generally performed to detect cell changes resulting from neoplastic or inflammatory conditions. Sputum specimens for cytological examinations may be collected by expectoration alone, by suctioning, by lung biopsy, during bronchoscopy, or by expectoration after bronchoscopy. A description of the method of specimen collection by bronchoscopy and biopsy is found in the monograph titled “Biopsy, Lung.”

INDICATIONS:

- Assist in the diagnosis of lung cancer
- Assist in the identification of *Pneumocystis carinii* in persons with AIDS
- Detect known or suspected fungal or parasitic infection involving the lung
- Detect known or suspected viral disease involving the lung
- Screen cigarette smokers for neoplastic (nonmalignant) cellular changes
- Screen patients with history of acute or chronic inflammatory or infectious lung disorders, which may lead to benign atypical or metaplastic changes

RESULT:

(Method: Microscopic examination)
The method of reporting results of cytology examinations varies according to the laboratory performing the test. Terms used to report results may include *negative* (no abnormal cells seen), *inflammatory*, *benign atypical*, *suspect for neoplasm*, and *positive for neoplasm*.

Positive findings in:

- Infections caused by fungi, ova, or parasites

- Lipoid or aspiration pneumonia, as seen by lipid droplets contained in macrophages
- Neoplasms
- Viral infections and lung disease

CRITICAL VALUES:

If the patient becomes hypoxic or cyanotic, remove catheter immediately and administer oxygen.

If patient has asthma or chronic bronchitis, watch for aggravated bronchospasms with use of normal saline or acetylcysteine in an aerosol. It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS:

- Improper specimen fixation may be cause for specimen rejection.
- Improper technique used to obtain bronchial washing may be cause for specimen rejection.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test helps identify cellular changes associated with neoplasms or organisms that result in respiratory tract infections. When the actual infectious organisms are identified by cytology, inform the patient that the findings will be confirmed by culture.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's immune and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Review the procedure with the patient. If the laboratory has provided a container with fixative, instruct the patient that the fixative contents of the specimen collection container should not be ingested or otherwise removed. Instruct the patient not to touch the edge or inside of the specimen container with the hands or mouth. Inform the patient that three samples may be required, on three separate mornings, either by passing a small tube (tracheal catheter) and adding suction or by expectoration. The time it takes to collect a proper specimen varies according to the level of cooperation of the patient and the specimen collection procedure. Address concerns about pain related to the procedure. Atropine is usually given before bronchoscopy examinations to reduce bronchial secretions and to prevent vagally induced bradycardia. Meperidine (Demerol) or morphine may be given as a sedative. Lidocaine is sprayed in the patient's throat to reduce discomfort caused by the presence of the tube.
- ▶ Reassure the patient that he or she will be able to breathe during the procedure if specimen collected is accomplished via suction method. Ensure that oxygen has been administered 20 to 30 min before the procedure if the specimen is to be obtained by tracheal suctioning.
- ▶ Assist in providing extra fluids, unless contraindicated, and proper humidification to loosen tenacious secretions. Inform the patient that increasing fluid intake before retiring on the night before the test aids in

- liquefying secretions and may make it easier to expectorate in the morning. Also explain that humidifying inspired air also helps to liquefy secretions.
- ▶ Assist with mouth care (brushing teeth or rinsing mouth with water), if needed, before collection so as not to contaminate the specimen by oral secretions.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during and after the procedure.
- ▶ For specimens collected by suctioning or expectoration without bronchoscopy, there are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ Instruct the patient to fast and refrain from taking liquids from midnight the night before if bronchoscopy or biopsy is to be performed. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the bronchoscopy or biopsy procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food and liquids have been restricted for at least 6 to 8 hr prior to the procedure.
- ▶ Have patient remove dentures, contact lenses, eyeglasses, and jewelry. Notify the HCP if the patient has permanent crowns on teeth. Have the patient remove clothing and change into a gown for the procedure.
- ▶ Have emergency equipment readily available. Keep resuscitation equipment on hand in the case of respiratory impairment or laryngospasm after the procedure.
- ▶ Avoid using morphine sulfate in those with asthma or other pulmonary disease. This drug can further exacerbate bronchospasms and respiratory impairment.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- Assist the patient to a comfortable position, and direct the patient to breathe normally during the beginning of the general anesthesia. Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date and time of collection, and any medication the patient is taking that may interfere with test results (e.g., antibiotics). Cytology specimens may also be expressed onto a glass slide and sprayed with a fixative or 95% alcohol.

Bronchoscopy:

- Record baseline vital signs.
- The patient is positioned in relation to the type of anesthesia being used. If local anesthesia is used, the patient is seated, and the tongue and oropharynx are sprayed and swabbed with anesthetic before the bronchoscope is inserted. For general anesthesia, the patient is placed in a supine position with the neck hyperextended. After anesthesia, the patient is kept in supine or shifted to side-lying position, and the bronchoscope is inserted. After inspection, the samples are collected from suspicious sites by bronchial brush or biopsy forceps.

Expectorated Specimen:

- Ask the patient to sit upright, with assistance and support (e.g., with an overbed table) as needed.
- Ask the patient to take two or three deep breaths and cough deeply. Any sputum raised should be expectorated directly into a sterile sputum collection container.
- If the patient is unable to produce the desired amount of sputum, several strategies may be attempted. One approach is to have the patient drink two glasses of water, and then

assume the position for postural drainage of the upper and middle lung segments. Effective coughing may be assisted by placing either the hands or a pillow over the diaphragmatic area and applying slight pressure.

- Another approach is to place a vaporizer or other humidifying device at the bedside. After sufficient exposure to adequate humidification, postural drainage of the upper and middle lung segments may be repeated before attempting to obtain the specimen.
- Other methods may include obtaining an order for an expectorant to be administered with additional water approximately 2 hr before attempting to obtain the specimen. Chest percussion and postural drainage of all lung segments may also be employed. If the patient is still unable to raise sputum, the use of an ultrasonic nebulizer ("induced sputum") may be necessary; this is usually done by a respiratory therapist.

Tracheal Suctioning:

- Obtain the necessary equipment, including a suction device, suction kit, and Lukens tube or in-line trap.
- Position the patient with head elevated as high as tolerated.
- Put on sterile gloves. Maintain the dominant hand as sterile and the nondominant hand as clean.
- Using the sterile hand, attach the suction catheter to the rubber tubing of the Lukens tube or in-line trap. Then attach the suction tubing to the male adapter of the trap with the clean hand. Lubricate the suction catheter with sterile saline.
- Tell nonintubated patients to protrude the tongue and to take a deep breathe as the suction catheter is passed through the nostril. When the catheter enters the trachea, a reflex cough is stimulated; immediately advance the catheter into the trachea and apply suction. Maintain suction for approximately 10 sec, but never longer than 15 sec. Withdraw the catheter without applying suction. Separate the suction catheter and suction tubing

from the trap, and place the rubber tubing over the male adapter to seal the unit.

- For intubated patients or patients with a tracheostomy, the previous procedure is followed except that the suction catheter is passed through the existing endotracheal or tracheostomy tube rather than through the nostril. The patient should be hyperoxygenated before and after the procedure in accordance with standard protocols for suctioning these patients.
- Generally, a series of three to five early-morning sputum samples are collected in sterile containers.

General:

- Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume usual diet, as directed by the HCP. Assess the patient's ability to swallow before allowing the patient to attempt liquids or solid foods.
- Inform the patient that he or she may experience some throat soreness and hoarseness. Instruct patient to treat throat discomfort with lozenges and warm gargles when the gag reflex returns.
- Monitor vital signs and compare with baseline values every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- Emergency resuscitation equipment should be readily available if the vocal cords become spastic after intubation.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia,

hyperpnea, hypertension, palpitations, nausea, or vomiting.

- Observe the patient for hemoptysis, difficulty breathing, cough, air hunger, excessive coughing, pain, or absent breathing sounds over the affected area. Report any symptoms to the HCP.
- Evaluate the patient for symptoms indicating the development of pneumothorax, such as dyspnea, tachypnea, anxiety, decreased breathing sounds, or restlessness. A chest x-ray may be ordered to check for the presence of this complication.
- Evaluate the patient for symptoms of empyema, such as fever, tachycardia, malaise, or elevated white blood cell count.
- Administer antibiotic therapy if ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- Nutritional considerations:** Malnutrition is commonly seen in patients with severe respiratory disease for numerous reasons including fatigue, lack of appetite, and gastrointestinal distress. Adequate intake of vitamins A and C are also important to prevent pulmonary infection and to decrease the extent of lung tissue damage.
- Recognize anxiety related to test results, and be supportive of impaired activity related to perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Lung Association (www.lungusa.org).
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient of smoking cessation programs, as appropriate. Inform the patient with abnormal findings of the importance of medical follow-up,

and suggest ongoing support resources to assist in coping with chronic illness and possible early death. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a

change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include arterial/alveolar oxygen ratio, biopsy lung, blood gases, bronchoscopy, complete blood count, CT thoracic, relevant cultures (fungal, mycobacteria, sputum, throat, viral), gallium scan, gram/acid-fast stain, lung perfusion scan, lung ventilation scan, MRI chest, mediastinoscopy, pleural fluid analysis, pulmonary function tests, and TB tests.
- ▶ Refer to the Immune and Respiratory System tables at the end of the book for related tests by body system.

Cytology, Urine

SYNONYM/ACRONYM: N/A.

SPECIMEN: Urine (180 mL for an adult or at least 10 mL for a child) collected in a clean wide-mouth plastic container.

REFERENCE VALUE: (Method: Microscopic examination) No abnormal cells or inclusions seen.

DESCRIPTION: Cytology is the study of the origin, structure, function, and pathology of cells. In clinical practice, cytological examinations are generally performed to detect cell changes resulting from neoplastic or inflammatory conditions. Cells from the epithelial lining of the urinary tract can be found in the urine. Examination of

these cells for abnormalities is useful with suspected infection, inflammatory conditions, or malignancy.

INDICATIONS:

- Assist in the diagnosis of urinary tract diseases, such as cancer, cytomegalovirus infection, and other inflammatory conditions

RESULT:**Positive findings in:**

- Cancer of the urinary tract
- Cytomegalic inclusion disease
- Inflammatory disease of the urinary tract

Negative findings in: N/A

CRITICAL VALUES:

It is essential that critical diagnoses be communicated immediately and directly from the pathologist to the health care provider (HCP). A listing of these diagnoses varies from facility to facility.

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify the presence of neoplasms of the urinary tract and assist in the diagnosis of urinary tract infections.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Review the procedure with the patient. If a catheterized specimen is to be collected, explain this procedure to the patient and obtain a catheterization tray. Address concerns about pain and explain that there

may be some discomfort during the catheterization.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date and time of collection, method of specimen collection, and any medications the patient has taken that may interfere with test results (e.g., antibiotics).

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Pediatric Urine Collector:

- ▶ Put on gloves. Appropriately cleanse the genital area, and allow the area to dry. Remove the covering over the adhesive strips on the collector bag and apply over the genital area. Diaper the child. After obtaining the specimen, place the entire collection bag in a sterile urine container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection.

Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Urinary Catheterization:

- ◆ Place female patient in lithotomy position or male patient in supine position. Using sterile technique, open the straight urinary catheterization kit and perform urinary catheterization. Place the retained urine in a sterile specimen container.

Suprapubic Aspiration:

- ◆ Place the patient in supine position. Cleanse the area with antiseptic, and drape with sterile drapes. A needle is inserted through the skin into the bladder. A syringe attached to the needle is used to aspirate the urine sample. The needle is then removed and a sterile dressing is applied to the site. Place the sterile sample in a sterile specimen container.
- ◆ Do not collect urine from the pouch from a patient with a urinary diversion (e.g., ileal conduit). Instead perform catheterization through the stoma.

General:

- ◆ Promptly transport the specimen to the laboratory for processing and analysis. If a delay in transport is expected, add an equal volume of 50% alcohol to the specimen as a preservative.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual medication as directed by the HCP.
- ◆ Instruct the patient to report symptoms such as pain related to tissue

inflammation, pain or irritation during void, bladder spasms, or alterations in urinary elimination.

- ◆ Observe for signs of inflammation if the specimen is obtained by suprapubic aspiration.
- ◆ Administer antibiotic therapy as ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ◆ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include biopsy kidney, bladder cancer markers, cystoscopy, CMV IgG and IgM, PAP smear, UA, and US bladder.
- ◆ Refer to the Genitourinary and Immune System tables at the end of the book for related tests by body system.

Cytomegalovirus, Immunoglobulin G and Immunoglobulin M

SYNONYM/ACRONYM: CMV.

SPECIMEN: Serum (1 mL) collected in a plain red-top tube.

REFERENCE VALUE: (Method: Indirect fluorescent antibody) Negative or less than a fourfold increase in titer.

DESCRIPTION: Cytomegalovirus (CMV) is a double-stranded DNA herpesvirus. The incubation period for primary infection is 4 to 8 wk. Transmission may occur by direct contact with oral, respiratory, or venereal secretions and excretions. CMV infection is of primary concern in pregnant or immunocompromised patients or patients who have recently received an organ transplant. Blood units are sometimes tested for the presence of CMV if patients in these high-risk categories are the transfusion recipients. CMV serology is part of the TORCH (toxoplasmosis, other [congenital syphilis and viruses], rubella, CMV, and herpes simplex type 2) panel used to test pregnant women. CMV, as well as these other infectious agents, can cross the placenta and result in congenital malformations, abortion, or stillbirth. The presence of immunoglobulin (Ig) M antibodies indicates acute infection. The presence of IgG antibodies indicates current or past infection.

INDICATIONS:

- Assist in the diagnosis of congenital CMV infection in newborns

- Determine susceptibility, particularly in pregnant women, immunocompromised patients, and patients who recently have received an organ transplant
- Screen blood for high-risk-category transfusion recipients

RESULT:

Positive findings in:

- *CMV infection*

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- False-positive results may occur in the presence of rheumatoid factor.
- False-negative results may occur if treatment was begun before antibodies developed or if the test was done less than 6 days after exposure to the virus.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of CMV infection.
- ♦ Obtain a history of the patient's complaints and history of exposure. Obtain

a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's immune and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that multiple specimens may be required. Any individual positive result should be repeated in 7 to 14 days to monitor a change in titer. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient in isolation precautions during time of communicability or contagion.
- ▶ Emphasize the need to return to have a convalescent blood sample taken in 7 to 14 days.
- ▶ Warn the patient that there is a possibility of false-negative or false-positive results.
- ▶ Recognize anxiety related to test results if the patient is pregnant, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include β_2 -microglobulin, bronchoscopy, chlamydia group antibody, culture viral, cytology urine, HIV-1/2 antibodies, PAP smear, rubella antibody, and *Toxoplasma* antibody.
- ▶ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

D-Dimer

SYNONYM/ACRONYM: Dimer, fibrin degradation fragment.

SPECIMEN: Plasma (1 mL) collected in a completely filled blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Latex semiquantitative screen or quantitative enzyme-linked immunosorbent assay [ELISA])

Semiquantitative: No fragments detected

Quantitative: Less than 250 ng/mL

DESCRIPTION: The D-dimer is an asymmetric carbon compound formed by a cross-link between two identical fibrin molecules. The test is specific for secondary fibrinolysis because the cross-linkage occurs with fibrin and not fibrinogen. A positive test is presumptive evidence of disseminated intravascular coagulation (DIC).

INDICATIONS:

- Assist in the detection of DIC and deep venous thrombosis (DVT)
- Assist in the evaluation of myocardial infarction (MI) and unstable angina
- Assist in the evaluation of possible veno-occlusive disease associated with sequelae of bone marrow transplant
- Assist in the evaluation of pulmonary embolism

RESULT:

The sensitivity and specificity of the assay varies among test kits and between test methods (e.g., latex vs. ELISA).

Increased in:

D-Dimers are formed in inflammatory conditions where plasmin

carries out its fibrinolytic action on a fibrin clot.

- Arterial or venous thrombosis
- DVT
- DIC
- Neoplastic disease
- Pre-eclampsia
- Pregnancy (late and postpartum)
- Pulmonary embolism
- Recent surgery (within 2 days)
- Secondary fibrinolysis

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- High rheumatoid factor titers can cause a false-positive result.
- Increased CA 125 levels can cause a false-positive result.
- Drugs that may cause an increase in plasma D-dimer include those administered for antiplatelet therapy.
- Drugs that may cause a decrease in plasma D-dimer include pravastatin and warfarin.
- Placement of tourniquet for longer than 1 min can result in venous stasis and changes in the concentration of plasma proteins to be measured. Platelet activation may also occur under these conditions, causing erroneous results.
- Vascular injury during phlebotomy can activate platelets and

coagulation factors, causing erroneous results.

- Hemolyzed specimens must be rejected because hemolysis is an indication of platelet and coagulation factor activation.
- Incompletely filled tubes contaminated with heparin or clotted specimens must be rejected.
- Icteric or lipemic specimens interfere with optical testing methods, producing erroneous results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used in the evaluation of acute MI and DIC and to detect DVT.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of hematological diseases and recent surgery.
- ▶ Obtain a history of the patient's cardiovascular, hematopoietic, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a 5-mL blue-top tube. Fill the tube completely. **Important note:** Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range.
- ▶ When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and nonadditive red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with tissue thromboplastin, which can falsely decrease values.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed samples stored in unopened tubes is that testing should be completed within 1 to 4 hr.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include aPTT, alveolar/arterial gradient, angiography pulmonary, antibodies anticardiolipin, AT-III, blood gases, coagulation factors, FDP, fibrinogen, lactic acid, lung perfusion scan, plasminogen, platelet count, plethysmography, protein S, PT/INR, US venous doppler extremity studies, and venography lower extremity studies.
- Refer to the Cardiovascular, Hematopoietic, and Respiratory System tables at the end of the book for related tests by body system.

Dehydroepiandrosterone Sulfate

SYNONYM/ACRONYM: DHEAS.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in lavender-top (EDTA) tube is also acceptable.

REFERENCE VALUE: (Method: Radioimmunoassay)

Age	Conventional Units mcg/dL	SI Units micromol/L (Conventional Units × 0.027)
Newborn		
Male	18–406	0.5–10.9
Female	10–248	0.3–6.7
1 mo–5 yr Male and Female	1–55	0.03–1.5
6–9 yr Male and Female	2.5–145	0.07–3.9
10–11 yr		
Male	15–115	0.4–3.1
Female	15–260	0.4–7.0
12–17 yr Male and Female	20–555	0.5–15.0
19–30 yr		
Male	125–619	3.4–16.7
Female	45–380	1.2–10.3
31–50 yr		
Male	59–452	1.6–12.2
Female	12–379	0.3–10.2
51–60 yr		
Male	20–413	0.5–11.1
61–83 yr		
Male	10–285	0.3–7.7
Postmenopausal woman	30–260	0.8–7.0

Tanner Stage	Male	Male SI Units	Female	Female
	Conventional Units mcg/dL	micromol/L	Conventional Units mcg/dL	SI Units micromol/L
I	5–265	0.1–7.2	5–125	0.1–3.4
II	15–380	0.4–10.3	15–150	0.4–4.0
III	60–505	1.6–13.6	20–535	0.5–14.4
IV	65–560	1.8–15.1	35–485	0.9–13.1
V	165–500	4.4–13.5	75–530	2.0–14.3

DESCRIPTION: Dehydroepiandrosterone sulfate (DHEAS) is the major precursor of 17-ketosteroids. DHEAS is a metabolite of DHEA, the principal adrenal androgen. DHEAS is primarily synthesized in the adrenal gland, with a small amount secreted by the testes. DHEAS is a weak androgen and can be converted into more potent androgens (e.g., testosterone) as well as estrogens (e.g., estradiol). It is secreted in concert with cortisol, under the control of adrenocorticotropic hormone (ACTH) and prolactin. Excessive production causes masculinization in women and children. DHEAS has replaced measurement of urinary 17-ketosteroids in the estimation of adrenal androgen production.

INDICATIONS:

- Assist in the evaluation of androgen excess, including congenital adrenal hyperplasia, adrenal tumor, and Stein-Leventhal syndrome
- Evaluate women with infertility, amenorrhea, or hirsutism

RESULT:

Increased in:

DHEAS is produced by the adrenal cortex and testis, therefore any condition stimulating these organs

or associated feedback mechanisms will result in increased levels.

- Anovulation
- Cushing's syndrome
- Ectopic ACTH-producing tumors
- Hirsutism
- Hyperprolactinemia
- Polycystic ovary (Stein-Leventhal syndrome)
- Virilizing adrenal tumors

Decreased in:

DHEAS is produced by the adrenal cortex and testis, therefore any condition suppressing the normal function of these organs or associated feedback mechanisms will result in decreased levels.

- Addison's disease
- Adrenal insufficiency (primary or secondary)
- Aging adults (*Natural decline in production with age*)
- Hyperlipidemia
- Pregnancy (*Related to DHEAS produced by fetal adrenals and converted to estrogens in the placenta*)
- Psoriasis (*Some potent topical medications used for long periods of time can result in chronic adrenal insufficiency*)
- Psychosis (*Related to acute adrenal insufficiency*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase DHEAS levels include clomiphene,

corticotropin, danazol, DHEA, mifepristone, and nitrendipine.

- Drugs that may decrease DHEAS levels include carbamazepine, dexamethasone, ketoconazole, oral contraceptives, and phenytoin.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in identifying the cause for infertility, amenorrhea, or hirsutism.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, phase of menstrual cycle, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, cortisol, prolactin, and testosterone.
- ▶ Refer to the Endocrine System table at the end of the book for related tests by body system.

Drugs of Abuse

Amphetamines	Ethanol (Alcohol)
Barbiturates	Opiates
Benzodiazepines	Phencyclidine
Cannabinoids	Tricyclic Antidepressants
Cocaine	

SYNONYM/ACRONYM: Amphetamines, barbiturates, benzodiazepines (tranquilizers), cannabinoids (THC), cocaine, ethanol (alcohol, ethyl alcohol, ETOH), phencyclidine (PCP), opiates (heroin), tricyclic antidepressants (TCA)

SPECIMEN: For ethanol, serum (1 mL) collected in a red-top tube; plasma (1 mL) collected in gray-top (sodium fluoride/potassium oxalate) tube is also acceptable. For drug screen, urine (15 mL) collected in a clean plastic container. Gastric contents (20 mL) may also be submitted for testing.

Workplace drug-screening programs, because of the potential medicolegal consequences associated with them, require collection of urine and blood specimens using a *chain of custody protocol*. The protocol provides securing the sample in a sealed transport device in the presence of the donor and a representative of the donor's employer, such that tampering would be obvious. The protocol also provides a written document of specimen transfer from donor to specimen collection personnel, to storage, to analyst, and to disposal.

REFERENCE VALUE: (Method: Spectrophotometry for ethanol; immunoassay for drugs of abuse)

Ethanol: None detected

Drug screen: None detected

DESCRIPTION: Drug abuse continues to be one of the most significant social and economic problems in the United States. The National Institute for Drug Abuse (NIDA) has identified opiates, cocaine, cannabinoids, amphetamines, and phencyclidines (PCPs) as the most commonly abused illicit drugs. Alcohol is the most commonly encountered legal substance of abuse. Chronic alcohol abuse can lead to liver disease, high blood pressure, cardiac disease, and birth defects.

INDICATIONS:

- Differentiate alcohol intoxication from diabetic coma, cerebral trauma, or drug overdose
- Investigate suspected drug abuse
- Investigate suspected drug overdose
- Investigate suspected noncompliance with drug or alcohol treatment program
- Monitor ethanol levels when administered to treat methanol intoxication
- Routine workplace screening

Cutoff Concentrations for Drugs of Abuse Recommended by NIDA

Amphetamines	1000 ng/mL
Barbiturates	300 ng/mL
Benzodiazepines	300 ng/mL
Cannabinoids	50 ng/mL
Cocaine	300 ng/mL
Opiates	300 ng/mL
Phencyclidine	25 ng/mL
Tricyclic antidepressants	1000 ng/mL

RESULT:

A urine screen merely identifies the presence of these substances in urine; it does not indicate time of exposure, amount used, quality of the source used, or level of impairment. Positive screens should be considered presumptive. Drug-specific confirmatory methods should be used to investigate questionable results of a positive urine screen.

CRITICAL VALUES: 

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms.

The legal limit for ethanol intoxication varies from state to state, but in most states greater than 80 mg/dL (0.08 G%) is considered impaired for driving. Levels greater than 300 mg/dL are associated with amnesia, vomiting, double vision, and hypothermia. Levels of 400 to 700 mg/dL are associated with coma and may be fatal. Possible interventions for ethanol toxicity include administration of tap water or 3% sodium bicarbonate lavage, breathing support, and hemodialysis (usually indicated only if levels exceed 300 mg/dL).

Barbiturate and benzodiazepine intoxication causes central nervous system (CNS) depression, which may progress to respiratory failure, hypotension, coma, and death. Do not induce emesis because of the

risk of aspiration. Possible interventions include airway protection, administration of oxygen, gastric lavage with water or saline (up to 24 hr after ingestion), administration of activated charcoal, and monitoring CNS depression.

PCP intoxication causes a variety of symptoms depending on the stage of intoxication. Stage I includes psychiatric signs, muscle spasms, fever, tachycardia, flushing, small pupils, salivation, nausea, and vomiting. Stage II includes stupor, convulsions, hallucinations, increased heart rate, and increased blood pressure. Stage III includes further increases of heart rate and blood pressure that may culminate in cardiac and respiratory failure. Possible interventions may include providing respiratory support, administration of activated charcoal with a cathartic such as sorbitol, gastric lavage and suction, administration of IV nutrition and electrolytes, and acidification of the urine to promote PCP excretion.

Cocaine intoxication causes short-term symptoms of CNS stimulation, hypertension, tachypnea, mydriasis, and tachycardia. Possible interventions include emesis (if orally ingested and if the patient has a gag reflex and normal CNS function), gastric lavage (if orally ingested), whole-bowel irrigation (if packs of the drug were ingested), airway protection, cardiac support, and administration of diazepam or phenobarbital for

convulsions. The use of, β -blockers is contraindicated.

Amphetamine intoxication causes psychoses, tremors, convulsions, insomnia, tachycardia, dysrhythmias, impotence, cerebrovascular accident, and respiratory failure. Possible interventions include emesis (if orally ingested and if the patient has a gag reflex and normal CNS function), administration of activated charcoal followed by magnesium citrate cathartic, acidification of the urine to promote excretion, and administration of liquids to promote urinary output.

Heroin is an opiate that at toxic levels causes bradycardia, flushing, itching, hypotension, hypothermia, and respiratory depression. Possible interventions include airway protection and the administration of naloxone (Narcan).

TCA intoxication causes confusion, agitation, hallucinations, seizures, dysrhythmias, hyperthermia, dilation of the pupils, and coma. Possible interventions may include administration of activated charcoal; gastric lavage with saline; IV administration of physostigmine (to counteract coma, hypertension, respiratory depression, and seizures); administration of bicarbonate (to control dysrhythmia); administration of propranolol, lidocaine, or phenytoin to control convulsions; and monitoring cardiac function.

INTERFERING FACTORS:

- Codeine-containing cough medicines and antidiarrheal preparations, as well as ingestion of large amounts of poppy seeds, may produce a false-positive opiate result.
- Adulterants such as bleach or other strong oxidizers can produce erroneous urine drug screen results.
- Alcohol is a volatile substance, and specimens should be stored in a tightly stoppered container to avoid falsely decreased values.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to rapidly identify commonly abused drugs in suspected drug overdose or for routine workplace drug screening.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of symptoms, previously performed laboratory tests, and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the entire procedure with the patient, especially if the circumstances require collection of urine and blood specimens using a chain of custody protocol. Inform the patient that specimen collection takes approximately 5 to 10 min but may vary depending on the level of patient cooperation. Address concerns about pain and explain that there may be some discomfort during the venipuncture but there should be no discomfort during urine specimen collection.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions.
- ◆ *Make sure a written and informed consent has been signed prior to the procedure.*

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient receiving venipuncture to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in

Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date, and time of collection. For alcohol level, use a non-alcohol-containing solution to cleanse the venipuncture site before specimen collection. Perform a venipuncture, as appropriate. Cadaver blood is taken from the aorta. For a urine drug screen, instruct the patient to obtain a clean-catch urine specimen.

- Remove the needle, and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

Clean-Catch Specimen:

- Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.
- Follow the chain of custody protocol, if required. Monitor specimen collection, labeling, and packaging to prevent tampering. This protocol may vary by institution.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Ensure that results are communicated to the proper individual, as indicated in the chain of custody protocol.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide support and information regarding detoxification programs, as appropriate. Provide contact information, if desired, for the National Institute on Drug Abuse (www.nida.nih.gov).
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Refer to the Therapeutic/Toxicology table at the end of the book for related tests.

D-Xylose Tolerance Test

SYNONYM/ACRONYM: N/A.

SPECIMEN: Plasma (1 mL) collected in gray-top (fluoride/oxalate) tube and urine (10 mL from a 5-hr collection) in a clean amber plastic container.

REFERENCE VALUE: (Method: Spectrophotometry)

Dose by Age	Conventional Units	SI Units
<i>Plasma</i>		
<i>(Conventional Units × 0.0666)</i>		
Adult dose		
25 g	Greater than 25 mg/dL	Greater than 1.7 mmol/L
5 g	Greater than 20 mg/dL	Greater than 1.3 mmol/L
Pediatric dose		
0.5 g/kg (max. 25 g)	Greater than 30 mg/dL	Greater than 2.0 mmol/L
<i>Urine</i>		
<i>(Conventional Units × 6.66)</i>		
Adult dose		
25 g	Greater than 4 g/5-hr collection	Greater than 26.6 mmol/5 hr
5 g	Greater than 1.2 g/5-hr collection	Greater than 8 mmol/5 hr
Pediatric dose		
0.5 g/kg (max. 25 g)	Greater than 16%–33% of dose	Greater than 16%–33% of dose

DESCRIPTION: The D-xylose tolerance test is used to screen for intestinal malabsorption of carbohydrates. D-Xylose is a pentose sugar not normally present in the blood in significant amounts. It is partially absorbed when ingested and normally passes unmetabolized in the urine.

INDICATIONS:

Assist in the diagnosis of malabsorption syndromes

RESULT:

Increased in: N/A

Decreased in:

Conditions that involve defective mucosal absorption of carbohydrates and other nutrients.

- Amyloidosis
- Bacterial overgrowth (**Sugar is consumed by bacteria**)
- Eosinophilic gastroenteritis
- Lymphoma
- Nontropical sprue (celiac disease, gluten-induced enteropathy)

- Parasitic infestations (*Giardia*, schistosomiasis, hookworm)
- Postoperative period after massive resection of the intestine
- Radiation enteritis
- Scleroderma
- Small bowel ischemia
- Tropical sprue
- Whipple's disease
- Zollinger-Ellison syndrome

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase urine D-xylose levels include phenazopyridine.
- Drugs and substances that may decrease urine D-xylose levels include acetylsalicylic acid, aminosalicic acid, arsenicals, colchicine, digitalis, ethionamide, gold, indomethacin, isocarboxazid, kanamycin, monoamine oxidase inhibitors, neomycin, and phenelzine.
- Poor renal function or vomiting may cause low urine values.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of intestinal malabsorption syndromes.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that activity will be restricted during the test. Obtain the pediatric patient's weight to calculate dose of D-xylose to be administered. Inform the patient that blood specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Inform the patient that all urine for a 5-hr period must be saved. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device.
- ▶ Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member

to add to the laboratory collection container.

- ▶ Numerous medications (e.g., acetylsalicylic acid, indomethacin, neomycin) interfere with the test and should be withheld, by medical direction, for 24 hr before testing.
- ▶ There are no fluid restrictions, unless by medical direction.
- ▶ The patient should fast for at least 12 hr before the test. In addition, the patient should refrain from eating foods containing pentose sugars such as fruits, jams, jellies, and pastries. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions; assure that food has been restricted for at least 12 hr prior to the procedure and medications have been withheld, by medical direction, for 24 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 a.m. and 8 a.m., if possible. Remind the patient

to remain supine and at rest throughout the duration of the test. Instruct the patient to collect all urine for a 5-hr period after administration of the D-xylose.

- Adults are given a 25-g dose of D-xylose dissolved in 250 mL of water to take orally. The dose for pediatric patient is calculated by weight up to a maximum of 25 g. The patient should drink an additional 250 mL of water as soon as the D-xylose solution has been taken. Some adult patients with severe symptoms may be given a 5-g dose, but the test results are less sensitive at the lower dose.
- If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage.
- Blood samples are collected 1 hr postdose for pediatric patients and 2 hr postdose for adults.
- Direct the patient to breathe normally and to avoid unnecessary movement. Perform a venipuncture, and collect the specimen in a 5-mL gray-top tube.
- Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that could affect test results.
- Promptly transport the specimens to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Instruct the patient to resume usual medications, as directed by the HCP.

- Nutritional considerations:** Decreased D-xylose levels may be associated with gastrointestinal disease. Nutritional therapy may be indicated in the presence of malabsorption disorders. Encourage the patient, as appropriate, to consult with a qualified nutrition specialist to plan a lactose- and gluten-free diet. This dietary planning is complex because patients are often malnourished and have related nutritional problems.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Offer support to help the patient and/or caregiver cope with the long-term implications of a chronic disorder and related lifestyle changes. Educate the patient regarding access to counseling services, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include biopsy intestine, chloride sweat, fecal analysis, fecal fat, gastric emptying scan, lactose tolerance, ova and parasite, and RAIU.
- Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Echocardiography

SYNONYM/ACRONYM: Doppler echo, Doppler ultrasound of the heart, echo.

AREA OF APPLICATION: Chest/thorax.

CONTRAST: Can be done with or without noniodinated contrast medium (microspheres).

DESCRIPTION: Echocardiography, a noninvasive ultrasound (US) procedure, uses high-frequency sound waves of various intensities to assist in diagnosing cardiovascular disorders. The procedure records the echoes created by the deflection of an ultrasonic beam off the cardiac structures and allows visualization of the size, shape, position, thickness, and movement of all four valves, atria, ventricular and atria septa, papillary muscles, chordae tendineae, and ventricles. This study can also determine blood-flow velocity and direction and the presence of pericardial effusion during the movement of the transducer over areas of the chest. Electrocardiography and phonocardiography can be done simultaneously to correlate the findings with the cardiac cycle. These procedures can be done at the bedside or in a specialized department, health care provider's (HPC's) office, or clinic.

Included in the study are the M-mode method, which produces a linear tracing of timed motions of the heart, its structures, and associated measurements over time; and the two-dimensional method, using real-time Doppler color-flow imaging with pulsed and continuous-wave Doppler spectral tracings, which produces a cross-section of the structures of the heart and their relationship to one another, including changes in the coronary vasculature,

velocity and direction of blood flow, and areas of eccentric blood flow. Doppler color-flow imaging may also be helpful in depicting the function of biological and prosthetic valves.

Cardiac contrast medium is used to aid in the diagnosis of intracardiac shunt and tricuspid valve regurgitation. The contrast agent is injected IV and outlines the chambers of the heart.

INDICATIONS:

- Detect atrial tumors (myxomas)
- Detect subaortic stenosis as evidenced either by displacement of the anterior atrial leaflet or by a reduction in aortic valve flow, depending on the obstruction
- Detect ventricular or atrial mural thrombi and evaluate cardiac wall motion after myocardial infarction
- Determine the presence of pericardial effusion, tamponade, and pericarditis
- Determine the severity of valvular abnormalities such as stenosis, prolapse, and regurgitation
- Evaluate congenital heart disorders
- Evaluate endocarditis
- Evaluate or monitor prosthetic valve function
- Evaluate the presence of shunt flow and continuity of the aorta and pulmonary artery
- Evaluate unexplained chest pain, electrocardiographic changes, and abnormal chest x-ray (e.g., enlarged cardiac silhouette)

- Evaluate ventricular aneurysms and/or thrombus
- Measure the size of the heart's chambers and determine if hypertrophic cardiomyopathy or congestive heart failure is present

RESULT:**Normal findings in:**

- Normal appearance in the size, position, structure, and movements of the heart valves visualized and recorded in a combination of ultrasound modes; and normal heart muscle walls of both ventricles and left atrium, with adequate blood filling. Established values for the measurement of heart activities obtained by the study may vary by HCP and institution.

Abnormal findings in:

- Aneurysm
- Aortic valve abnormalities
- Cardiac neoplasm
- Cardiomyopathy
- Congenital heart defect
- Congestive heart failure
- Coronary artery disease
- Endocarditis
- Mitral valve abnormalities
- Myxoma
- Pericardial effusion, tamponade, and pericarditis
- Pulmonary hypertension
- Pulmonary valve abnormalities
- Septal defects
- Ventricular hypertrophy
- Ventricular or atrial mural thrombi

CRITICAL VALUES:

- Aneurysm
- Infection
- Obstruction
- Tumor with significant mass effect (Rare)

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:**Factors that may impair clear imaging:**

- Incorrect placement of the transducer over the desired test site
- Retained barium from a previous radiological procedure
- Patients who are dehydrated, resulting in failure to demonstrate the boundaries between organs and tissue structures
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- The presence of chronic obstructive pulmonary disease or use of mechanical ventilation, which increases the air between the heart and chest wall (hyperinflation) and can attenuate the ultrasound waves
- The presence of arrhythmias
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses cardiac function.
- ▶ Obtain a history of the patient's symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). Ensure that barium studies were performed at least 24 hr before this test.

- Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- Obtain a list of the patient's current medications, including herbs, nutritional supplements and nutraceuticals (see Appendix F).
- Review the procedure with the patient. Address concerns about pain related to the procedure and explain that there should be no discomfort during the procedure. Inform the patient the procedure is performed in an US or cardiology department, usually by a HCP, and takes approximately 30 to 60 min.
- Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- Instruct the patient to remove jewelry, and other metallic objects from the area to be examined.
- There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- Have emergency equipment readily available.
- Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- Observe standard precautions, and follow the general guidelines in Appendix A.
- Place the patient in a supine position on a flat table with foam wedges to help maintain position and immobilization.
- Expose the chest, and attach electrocardiogram leads for simultaneous tracings, if desired.
- Apply conductive gel to the chest. Place the transducer on the chest surface along the left sternal border, the subxiphoid area, suprasternal

notch, and supraclavicular areas to obtain views and tracings of the portions of the heart. Scan the areas by systematically moving the probe in a perpendicular position to direct the ultrasound waves to each part of the heart.

- To obtain different views or information about heart function, position the patient on the left side and/or sitting up, or request that the patient breathe slowly or hold the breathe during the procedure. To evaluate heart function changes, the patient may be asked to inhale amyl nitrate (vasodilator).
- Administer contrast medium, if ordered. A second series of images is obtained.

POST-TEST:

- A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- When the study is completed, remove the gel from the skin.
- Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, atrial natriuretic peptide, BNP, blood gases, blood pool imaging, calcium, chest x-ray, cholesterol (total, HDL, LDL), CT cardiac scoring, CT thorax, CRP, CK and isoenzymes, echocardiography, echocardiography transesophageal, electrocardiogram,

exercise stress test, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isos, lipoprotein electrophoresis, lung perfusion scan, magnesium, MRI chest, MI infarct scan, myocardial perfusion

heart scan, myoglobin, PET heart, potassium, pulse oximetry, sodium, triglycerides, and troponin.

◆ Refer to the Cardiovascular System table in the back of the book for related tests by body system.

Echocardiography, Transesophageal

E

SYNONYM/ACRONYM: Echo, TEE.

AREA OF APPLICATION: Chest/thorax.

CONTRAST: Can be done with or without noniodinated contrast medium (microspheres).

DESCRIPTION: Transesophageal echocardiography (TEE) is performed to assist in the diagnosis of cardiovascular disorders when noninvasive echocardiography is contraindicated or does not reveal enough information to confirm a diagnosis. Noninvasive echocardiography may be an inadequate procedure for patients who are obese, have chest wall structure abnormalities, or have chronic obstructive pulmonary disease (COPD). TEE provides a better view of the posterior aspect of the heart, including the atrium and aorta. It is done with a transducer attached to a gastroscope that is inserted into the esophagus. The transducer and the ultrasound (US) instrument allow the beam to be directed to the back of the heart. The echoes are amplified and recorded on a screen for visualization, and recorded on graph paper or videotape. The depth of the endoscope and movement of the transducer is controlled to obtain various images of the heart structures. TEE is usually

performed during surgery; it is also used on patients who are in the intensive care unit, in whom the transmission of waves to and from the chest has been compromised and more definitive information is needed. The images obtained by TEE have better resolution than those obtained by routine transthoracic echocardiography because TEE uses higher frequency sound waves and offers closer proximity of the transducer to the cardiac structures. Cardiac contrast medium is used to improve the visualization of viable myocardial tissue within the heart.

INDICATIONS:

- Confirm diagnosis if conventional echocardiography does not correlate with other findings
- Detect and evaluate congenital heart disorders
- Detect atrial tumors (myxomas)
- Detect or determine the severity of valvular abnormalities and regurgitation

- Detect subaortic stenosis as evidenced by displacement of the anterior atrial leaflet and reduction in aortic valve flow, depending on the obstruction
- Detect thoracic aortic dissection and coronary artery disease (CAD)
- Detect ventricular or atrial mural thrombi and evaluate cardiac wall motion after myocardial infarction
- Determine the presence of pericardial effusion
- Evaluate aneurysms and ventricular thrombus
- Evaluate or monitor biological and prosthetic valve function
- Evaluate septal defects
- Measure the size of the heart's chambers and determine if hypertrophic cardiomyopathy or congestive heart failure is present
- Monitor cardiac function during open heart surgery (most sensitive method for monitoring ischemia)
- Re-evaluate after inadequate visualization with conventional echocardiography as a result of obesity, trauma to or deformity of the chest wall, or lung hyperinflation associated with COPD
- Congenital heart defects
- Congestive heart failure
- Mitral valve abnormalities
- Myocardial infarction
- Myxoma
- Pericardial effusion
- Pulmonary hypertension
- Pulmonary valve abnormalities
- Septal defects
- Shunting of blood flow
- Thrombus
- Ventricular hypertrophy
- Ventricular or atrial mural thrombi

CRITICAL VALUES:

- Aneurysm
- Aortic dissection

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients with significant esophageal pathology (procedure may cause bleeding)

Factors that may impair clear imaging:

- Incorrect placement of the transducer over the desired test site
- Retained barium from a previous radiological procedure
- Patients who are dehydrated, resulting in failure to demonstrate the boundaries between organs and tissue structures
- Laryngospasm, dysrhythmias, or esophageal bleeding
- Known upper esophageal pathology
- Conditions such as esophageal dysphagia and irradiation of the mediastinum
- The presence of COPD or use of mechanical ventilation, which increases the air between the heart and chest wall (hyperinflation) and can attenuate the ultrasound waves

RESULT:***Normal findings in:***

- Normal appearance of the size, position, structure, movements of the heart valves and heart muscle walls, and chamber blood filling; and no evidence of valvular stenosis or insufficiency, cardiac tumor, foreign bodies, or CAD. The established values for the measurement of heart activities obtained by the study may vary by health care provider (HCP) and institution.

Abnormal findings in:

- Aneurysm
- Aortic valve abnormalities
- CAD
- Cardiomyopathy

- The presence of arrhythmias
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

E

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses cardiac function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). Ensure that barium studies were performed at least 24 hr before this test.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure. Explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort during insertion of the scope. Lidocaine is sprayed in the patient's throat to reduce discomfort

caused by the presence of the endoscope. Inform the patient that the procedure is performed in a US or cardiology department, usually by a HCP, and takes approximately 30 to 60 min.

- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should avoid food and fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and fluid restriction for at least 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Obtain and record the patient's vital signs.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Ask patient as appropriate, to remove his or her dentures.
- ▶ Monitor pulse oximetry to determine oxygen saturation in sedated patients.
- ▶ Expose the chest, and attach electrocardiogram leads for simultaneous tracings, if desired.
- ▶ Spray or swab the patient's throat with a local anesthetic, and place the oral bridge device in the mouth to prevent biting of the endoscope.

- Place the patient in a left side-lying position on a flat table with foam wedges to help maintain position and immobilization. The pharyngeal area is anesthetized and the endoscope with the ultrasound device attached to its tip is inserted 30 to 50 cm to the posterior area of the heart, as in any esophagogastroduodenoscopy procedure.
- Ask the patient to swallow as the scope is inserted. When the transducer is in place, the scope is manipulated by controls on the handle to obtain scanning that provides real-time images of the heart motion and recordings of the images for viewing. Actual scanning is usually limited to 15 min or until the desired number of image planes is obtained at different depths of the scope.
- Administer contrast medium, if ordered. A second series of images is obtained.

POST-TEST:

- A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
 - Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
 - Instruct the patient to resume usual diet and activity 4 to 6 hr after the test, as directed by the HCP.
 - Instruct patient to treat throat discomfort with lozenges and warm gargles when the gag reflex returns.
- Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, atrial natriuretic peptide, BNP, blood gases, blood pool imaging, calcium, chest x-ray, cholesterol (total, HDL, LDL), CT cardiac scoring, CT thorax, CRP, CK and isoenzymes, echocardiography, electrocardiogram, exercise stress test, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isos, lipoprotein electrophoresis, lung perfusion scan, magnesium, MRI chest, MI infarct scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, pulse oximetry, sodium, triglycerides, and troponin.
- Refer to the Cardiovascular System table in the back of the book for related tests by body system.

Electrocardiogram

SYNONYM/ACRONYM: ECG, VCG, EKG.

AREA OF APPLICATION: Heart.

CONTRAST: None.

DESCRIPTION: The cardiac muscle consists of three layers of cells: the inner layer called the *endocardium*, the middle layer called the *myocardium*, and the outer layer called the *epicardium*. The systolic phase of the cardiac cycle reflects the contraction of the myocardium, whereas the diastolic phase takes place when the heart relaxes to allow blood to rush in. All muscle cells have a characteristic rate of contraction called *depolarization*. Therefore, the heart will maintain a predetermined heart rate unless other stimuli are received.

The monitoring of pulse and blood pressure evaluates only the mechanical activity of the heart. The electrocardiogram (ECG), a noninvasive study, measures the electrical currents or impulses that the heart generates during a cardiac cycle (see figure of a normal ECG at end of monograph). Electrical impulses travel through a conduction system beginning with the sinoatrial (SA) node and moving to the atrioventricular (AV) node via internodal pathways. From the AV node, the impulses travel to the bundle of His and onward to the right and left bundle branches. These bundles are located within the right and left ventricles. The impulses continue to the cardiac muscle cells by terminal fibers called *Purkinje fibers*. The ECG is a graphic display of the electrical activity of the heart, which is analyzed by time intervals and segments. Continuous tracing of the cardiac cycle activities is captured as heart cells are electrically stimulated, causing depolarization and movement of the activity through the cells of the myocardium.

The ECG study is completed by using 12 electrodes attached to the skin surface to obtain the total electrical activity of the

heart. Each lead records the electrical potential between the limbs or between the heart and limbs. The ECG machine records and marks the 12 leads on the strip of paper in the machine in proper sequence, usually 6 in. of the strip for each lead. The ECG pattern, called a *heart rhythm*, is recorded by a machine as a series of waves, intervals, and segments, each of which pertains to a specific occurrence during the contraction of the heart. The ECG tracings are recorded on graph paper using vertical and horizontal lines for analysis and calculations of time, measured by the vertical lines (1 mm apart and 0.04 sec per line), and of voltage, measured by the horizontal lines (1 mm apart and 0.5 mV per 5 squares). A pulse rate can be calculated from the ECG strip to obtain the beats per minute. The P wave represents the depolarization of the atrial myocardium; the QRS complex represents the depolarization of the ventricular myocardium; the P-R interval represents the time from beginning of the excitation of the atrium to the beginning of the ventricular excitation; and the ST segment has no deflection from baseline, but in an abnormal state may be elevated or depressed. An abnormal rhythm is called an *arrhythmia*.

INDICATIONS:

- Assess the extent of congenital heart disease
- Assess the extent of myocardial infarction (MI) or ischemia, as indicated by abnormal ST segment, interval times, and amplitudes
- Assess the function of heart valves
- Assess global cardiac function
- Detect arrhythmias, as evidenced by abnormal wave deflections

- Detect pericarditis, shown by ST segment changes or shortened P-R interval
- Determine electrolyte imbalances, as evidenced by short or prolonged Q-T interval
- Determine hypertrophy of the chamber of the heart or heart hypertrophy, as evidenced by P or R wave deflections
- Evaluate and monitor cardiac pacemaker function
- Evaluate and monitor the effect of drugs, such as digitalis, antiarrhythmics, or vasodilating agents
- Monitor ECG changes during an exercise test
- Monitor rhythm changes during the recovery phase after an MI

RESULT:

Normal findings in:

- Normal heart rate according to age: range of 60 to 100 beats/min in adults
- Normal, regular rhythm and wave deflections with normal measurement of ranges of cycle components and height, depth, and duration of complexes as follows:
P wave: 0.12 sec or 3 small blocks with amplitude of 2.5 mm
Q wave: less than 0.04 mm
R wave: 5 to 27 mm amplitude, depending on lead
T wave: 1 to 13 mm amplitude, depending on lead
QRS complex: 0.12 sec or 3 small blocks
ST segment: 1 mm

Abnormal findings in:

- Arrhythmias.
- Atrial or ventricular hypertrophy.
- Bundle branch block.
- Electrolyte imbalances.
- MI or ischemia.
- Pericarditis.
- Pulmonary infarction.
- P wave: An enlarged P wave deflection could indicate atrial enlargement. An absent or altered P wave could suggest that the

electrical impulse did not come from the SA node.

- P-R interval: An increased interval could imply a conduction delay in the AV node.
- QRS complex: An enlarged Q wave may indicate an old infarction; an enlarged deflection could indicate ventricular hypertrophy. Increased time duration may indicate a bundle branch block.
- ST segment: A depressed ST segment indicates myocardial ischemia. An elevated ST segment may indicate an acute MI or pericarditis. A prolonged ST segment may indicate hypocalcemia or hypokalemia (short segment).
- T wave: A flat or inverted T wave may indicate myocardial ischemia, infarction, or hypokalemia. A tall T wave may indicate hyperkalemia.

CRITICAL VALUES:

- Acute changes in ST elevation may indicate acute MI or pericarditis
- Bradycardia (less than 40 beats per min)
- PVCs greater than three in a row, pauses greater than 3 sec, or identified blocks
- Tachycardia (greater than 120 beats per min), supraventricular tachycardia, and ventricular tachycardia

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- Anatomic variation of the heart (i.e., the heart may be rotated in both the horizontal and frontal planes)
- Distortion of cardiac cycles due to age, gender, weight, or a medical condition (e.g., infants, women [may exhibit slight ST segment depression], obese patients, pregnant patients, patients with ascites)

- High intake of carbohydrates or electrolyte imbalances of potassium or calcium
- Improper placement of electrodes or inadequate contact between skin and electrodes because of insufficient conductive gel or poor placement, which can cause ECG tracing problems
- ECG machine malfunction or interference from electromagnetic waves in the vicinity
- Inability of the patient to remain still during the procedure, because movement, muscle tremor, or twitching can affect accurate test recording
- Increased patient anxiety, causing hyperventilation or deep respirations
- Medications such as barbiturates and digitalis
- Strenuous exercise before the procedure

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses cardiac function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums. Ask if the patient has had a heart transplant or pacemaker implanted.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that there should be no discomfort related to the procedure. Inform the patient that the procedure is performed by a health care provider (HCP) and takes approximately 15 min.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ No food, fluid, or medication restrictions exist, unless by medical direction.

INTRATEST:

- ▶ Ensure the patient has complied with pretesting preparations.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline values.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place patient in a supine position. Expose and appropriately drape the chest, arms, and legs.
- ▶ Prepare the skin surface with alcohol and remove excess hair. Shaving may be necessary. Dry skin sites.
- ▶ Apply the electrodes in the proper position. When placing the six unipolar chest leads, place V_1 at the fourth intercostal space at the border of the right sternum, V_2 at the fourth intercostal space at the border of the left sternum, V_3 between V_2 and V_4 , V_4 at the fifth intercostal space at the midclavicular line, V_5 at the left anterior axillary line at the level of V_4 horizontally, and V_6 at the level of V_4 horizontally and at the left midaxillary line. The wires are connected to the matched electrodes and the ECG machine. Chest leads (V_1 , V_2 , V_3 , V_4 , V_5 , and V_6) record data from the horizontal plane of the heart.
- ▶ Place three limb bipolar leads (two electrodes combined for each) on the arms and legs. Lead I is the combination of two arm electrodes, lead II is the combination of right arm and left leg electrodes, and lead III is the combination of left arm and left leg electrodes. Limb leads (I, II, III, aVL,

aV_F, and aV_R) record data from the frontal plane of the heart.

- ▶ The machine is set and turned on after the electrodes, grounding, connections, paper supply, computer, and data storage device are checked.
- ▶ If the patient has any chest discomfort or pain during the procedure, mark the ECG strip indicating that occurrence.

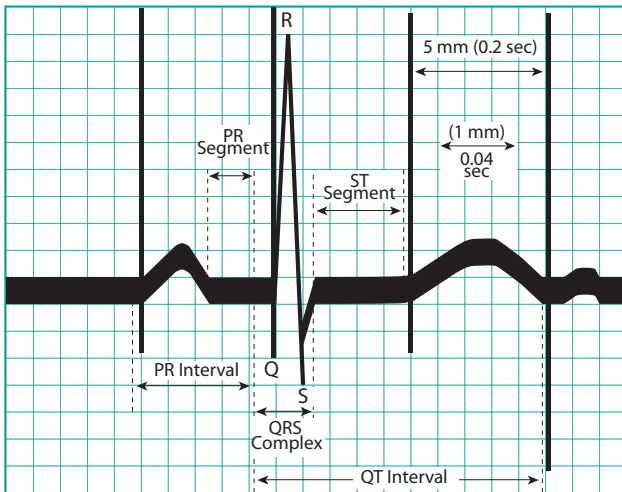
POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the procedure is complete, remove the electrodes and clean the skin where the electrode pads were applied.
- ▶ Evaluate the results in relation to previously performed ECGs. Denote cardiac rhythm abnormalities on the strip.
- ▶ Monitor vital signs and compare with baseline values. Protocols may vary from facility to facility.
- ▶ Instruct the patient to immediately notify a HCP of chest pain, changes in pulse rate, or shortness of breathe.
- ▶ Recognize anxiety related to the test results and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, atrial natriuretic peptide, BNP, blood gases, blood pool imaging, calcium, chest x-ray, cholesterol (total, HDL, LDL), CT cardiac scoring, CT thorax, CRP, CK and isoenzymes, echocardiography, echocardiography trans-esophageal, exercise stress test, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isos, lipoprotein electrophoresis, lung perfusion scan, magnesium, MRI chest, MI infarct scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, pulse oximetry, sodium, triglycerides, and troponin.
- ▶ Refer to the Cardiovascular System table in the back of the book for related tests by body system.



Electroencephalography

SYNONYM/ACRONYM: Sonogram (for sleep disturbances), EEG.

AREA OF APPLICATION: Brain.

CONTRAST: None.

DESCRIPTION: Electroencephalography (EEG) is a noninvasive study that measures the brain's electrical activity and records that activity on graph paper. These electrical impulses arise from the brain cells of the cerebral cortex. Electrodes, placed at 8 to 20 sites (or pairs of sites) on the patient's scalp, transmit the different frequencies and amplitudes of the brain's electrical activity to the EEG machine, which records the results in graph form on a moving paper strip. This procedure can evaluate responses to various stimuli, such as flickering light, hyperventilation, auditory signals, or somatosensory signals generated by skin electrodes. The procedure is usually performed in a room designed to eliminate electrical interference and minimize distractions. EEG can be done at the bedside, especially to confirm brain death. A health care provider (HCP) analyzes the waveforms. The test is used to detect epilepsy, intracranial abscesses, or tumors; to evaluate cerebral involvement due to head injury or meningitis; and to monitor for cerebral tissue ischemia during surgery when cerebral vessels must be occluded. EEG is also used to confirm brain death, which can be defined as absence of electrical activity in the brain. To evaluate abnormal EEG waves further, the patient may be

connected to an ambulatory EEG system similar to a Holter monitor for the heart. Patients keep a journal of their activities and any symptoms that occur during the monitoring period.

INDICATIONS:

- Confirm brain death
- Confirm suspicion of increased intracranial pressure caused by trauma or disease
- Detect cerebral ischemia during endarterectomy
- Detect intracranial cerebrovascular lesions, such as hemorrhages and infarcts
- Detect seizure disorders and identify focus of seizure and seizure activity, as evidenced by abnormal spikes and waves recorded on the graph
- Determine the presence of tumors, abscesses, or infection
- Evaluate the effect of drug intoxication on the brain
- Evaluate sleeping disorders, such as sleep apnea and narcolepsy
- Identify area of abnormality in dementia

RESULT:

Normal findings in:

- Normal occurrences of alpha, beta, theta, and delta waves (rhythms varying depending on the patient's age)
- Normal frequency, amplitude, and characteristics of brain waves

Abnormal findings in:

- Abscess
- Brain death
- Cerebral infarct
- Encephalitis
- Glioblastoma and other brain tumors
- Head injury
- Hypocalcemia or hypoglycemia
- Intracranial hemorrhage
- Meningitis
- Migraine headaches
- Narcolepsy
- Seizure disorders (grand mal, focal, temporal lobe, myoclonic, petit mal)
- Sleep apnea

CRITICAL VALUES:

- Abscess
- Brain death
- Head injury
- Hemorrhage
- Intracranial hemorrhage

Note and immediately report to the HCP abnormal results and related symptoms.

INTERFERING FACTORS:**Factors that may impair the results of the examination:**

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Drugs and substances such as sedatives, anticonvulsants, anxiolytics, alcohol, and stimulants such as caffeine and nicotine
- Hypoglycemic or hypothermic states
- Hair that is dirty, oily, or sprayed or treated with hair preparations

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the procedure is performed to measure electrical activity of the brain.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.

- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and assure the patient there is no discomfort during the procedure, but that, if needle electrodes are used, a slight pinch may be felt. Explain that electricity flows from the patient's body, not into the body, during the procedure. Explain that the procedure reveals brain activity only, not thoughts, feelings, or intelligence. Inform the patient the procedure is performed in a neurodiagnostic department, usually by a HCP and support staff, and takes approximately 30 to 60 min.

- ▶ Inform the patient that he or she may be asked to alter breathing pattern; be asked to follow simple commands such as opening or closing eyes, blinking, or swallowing; be stimulated with bright light; or be given a drug to induce sleep during the study.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ Instruct the patient to clean the hair and to refrain from using hair sprays, creams, or solutions before the test.

- ▶ Instruct the patient to limit sleep to 5 hr for an adult and 7 hr for a child the night before the study. Young infants and children should not be allowed to nap before the study.

- ▶ Instruct the patient to eat a meal before the study and to avoid stimulants such as caffeine and nicotine for 8 hr prior to the procedure. Under medical direction, the patient should avoid sedatives, anticonvulsants,

anxiolytics, and alcohol for 24 to 48 hr before the test.

- ◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ◆ Ensure the patient has complied with pretesting preparations. Ensure that caffeine-containing beverages were withheld for 8 hr before the procedure, and that a meal was ingested before the study.
- ◆ Ensure that all substances with the potential to interfere with test results were withheld for 24 to 48 hr before the test.
- ◆ Ensure that the patient is able to relax; report any extreme anxiety or restlessness.
- ◆ Ensure that hair is clean and free of hair sprays, creams, or solutions.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.
- ◆ Place the patient in the supine position in a bed or in a semi-Fowler's position on a recliner in a special room protected from any noise or electrical interferences that could affect the tracings.
- ◆ Remind the patient to relax and not to move any muscles or parts of the face or head. The HCP should be able to observe the patient for movements or other interferences through a window into the test room.
- ◆ The electrodes are prepared and applied to the scalp. Electrodes are placed in as many as 16 locations over the frontal, temporal, parietal, and occipital areas, and amplifier wires are attached. An electrode is also attached to each earlobe as grounding electrodes. At this time, a baseline recording can be made with the patient at rest.
- ◆ Recordings are made with the patient at rest and with eyes closed. Recordings are stopped about every 5 min to allow the patient to move. Recordings are also made during a drowsy and sleep period, depending on the patient's clinical condition and symptoms.
- ◆ Procedures (e.g., stroboscopic light stimulation, hyperventilation to induce alkalosis, and sleep induction by

administration of sedative to detect abnormalities that occur only during sleep) may be done to bring out abnormal electrical activity or other brain abnormalities.

- ◆ Observations for seizure activity are carried out during the study, and a description and time of activity is noted by the HCP.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ When the procedure is complete, remove electrodes from the hair and remove paste by cleansing with oil or witch hazel.
- ◆ If a sedative was given during the test, allow the patient to recover. Bedside rails are put in the raised position for safety.
- ◆ Instruct the patient to resume medications, as directed by the HCP.
- ◆ Instruct the patient to report any seizure activity.
- ◆ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include CSF analysis, CT brain, evoked brain potentials (SER, VER), MRI brain, and PET brain.
- ◆ Refer to the Musculoskeletal System table in the back of the book for related tests by body system.

Electromyography

SYNONYM/ACRONYM: Electrodiagnostic study, neuromuscular junction testing, EMG.

AREA OF APPLICATION: Muscles.

CONTRAST: None.

DESCRIPTION: Electromyography (EMG) measures skeletal muscle activity during rest, voluntary contraction, and electrical stimulation. Percutaneous extracellular needle electrodes containing fine wires are inserted into selected muscle groups to detect neuromuscular abnormalities and measure nerve and electrical conduction properties of skeletal muscles. The electrical potentials are amplified, displayed on a screen in waveforms, and electronically recorded, similar to electrocardiography. Comparison and analysis of the amplitude, duration, number, and configuration of the muscle activity provide diagnostic information about the extent of nerve and muscle involvement in the detection of primary muscle diseases, including lower motor neuron, anterior horn cell, or neuromuscular junction diseases; defective transmission at the neuromuscular junction; and peripheral nerve damage or disease. Responses of a relaxed muscle are electrically silent, but spontaneous muscle movement such as fibrillation and fasciculation can be detected in a relaxed, denervated muscle. Muscle action potentials are detected with minimal or maximal muscle contractions. The differences in the size and numbers of activity potentials during voluntary

contractions determine whether the muscle weakness is a disease of the striated muscle fibers or cell membranes (myogenic), or a disease of the lower motor neuron (neurogenic). Nerve conduction studies (electroneurography) are commonly done in conjunction with electromyography; the combination of the procedures is known as electromyoneurography. The examination's major use lies in differentiating among the following disease classes: primary myopathy, peripheral motor neuron disease, and disease of the neuromuscular junction.

INDICATIONS:

- Assess primary muscle diseases affecting striated muscle fibers or cell membrane, such as muscular dystrophy or myasthenia gravis
- Detect muscle disorders caused by diseases of the lower motor neuron involving the motor neuron on the anterior horn of the spinal cord, such as anterior poliomyelitis, amyotrophic lateral sclerosis, amyotonia, and spinal tumors
- Detect muscle disorders caused by diseases of the lower motor neuron involving the nerve root, such as Guillain-Barré syndrome, herniated disc, or spinal stenosis
- Detect neuromuscular disorders, such as peripheral neuropathy

caused by diabetes or alcoholism, and locate the site of the abnormality

- Determine if a muscle abnormality is caused by the toxic effects of drugs (e.g., antibiotics, chemotherapy) or toxins (e.g., *Clostridium botulinum*, snake venom, heavy metals)
- Differentiate between primary and secondary muscle disorders or between neuropathy and myopathy
- Differentiate secondary muscle disorders caused by polymyositis, sarcoidosis, hypocalcemia, thyroid toxicity, tetanus, and other disorders
- Monitor and evaluate progression of myopathies or neuropathies, including confirmation of diagnosis of carpal tunnel syndrome

RESULT:

Normal findings in:

- Normal muscle electrical activity during rest and contraction states

Abnormal findings in:

- Evidence of neuromuscular disorders or primary muscle disease (*Note:* findings must be correlated with the patient's history, clinical features, and results of other neurodiagnostic tests):

Amyotrophic lateral sclerosis

Bell's palsy

Beriberi

Carpal tunnel syndrome

Dermatomyositis

Diabetic peripheral neuropathy

Eaton-Lambert syndrome

Guillain-Barré syndrome

Multiple sclerosis

Muscular dystrophy

Myasthenia gravis

Myopathy

Polymyositis

Radiculopathy

Traumatic injury

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with extensive skin infection
- Patients receiving anticoagulant therapy
- Patients with an infection at the sites of electrode placement

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Age-related decreases in electrical activity
- Medications such as muscle relaxants, cholinergics, and anticholinergics
- Improper placement of surface or needle electrodes

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient the procedure is performed to measure electrical activity of the muscles.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ♦ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Address concerns about pain related to the procedure and warn the patient the procedure may be uncomfortable, but an analgesic or sedative will be administered. Inform the patient that as many as 10 electrodes may be inserted at various locations on the body. Inform the patient the procedure is performed in a special laboratory by

a health care provider (HCP) and takes approximately 1–3 hr to complete, depending on the patient's condition.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Assess for the ability to comply with directions given for exercising during the test.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ Under medical direction, the patient should avoid muscle relaxants, cholinergics, and anticholinergics for 3 to 6 days before the test.
- ▶ Instruct the patient to refrain from smoking and drinking caffeine-containing beverages for 3 hr before the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has refrained from smoking and drinking caffeine-containing beverages for 3 hr before the procedure.
- ▶ Ensure medications such as muscle relaxants, cholinergics, and anticholinergics have been withheld, as ordered.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Ask the patient to remain very still and relaxed and to cooperate with instructions given to contract muscles during the procedure.
- ▶ Place the patient in a supine or sitting position depending on the location of the muscle to be tested. Ensure that the area or room is protected from noise or metallic interference that may affect the test results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer mild analgesic (adult) or sedative (children), as ordered, to promote a restful state before the procedure.
- ▶ Cleanse the skin thoroughly with alcohol pads, as necessary.

- ▶ An electrode is applied to the skin to ground the patient, and then 24-gauge needles containing a fine-wire electrode are inserted into the muscle. The electrical potentials of the muscle are amplified, displayed on a screen, and electronically recorded.
- ▶ During the test, muscle activity is tested while the patient is at rest, during incremental needle insertion, and during varying degrees of muscle contraction.
- ▶ Ask the patient to alternate between a relaxed and a contracted muscle state, or to perform progressive muscle contractions while the potentials are being measured.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the procedure is complete, remove the electrodes and clean the skin where the electrode was applied.
- ▶ Monitor electrode sites for bleeding, hematoma, or inflammation.
- ▶ If residual pain is noted after the procedure, instruct the patient to apply warm compresses and to take analgesics, as ordered.
- ▶ Instruct the patient to resume usual diet, medication, and activity, as directed by the HCP.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include acetylcholine receptor antibody, biopsy muscle, CSF analysis, CT brain, CK, ENG, evoked brain potentials (SER, VER), MRI brain, plethysmography, and PET brain.
- ▶ Refer to the Musculoskeletal System table in the back of the book for related tests by body system.

Electromyography, Pelvic Floor Sphincter

SYNONYM/ACRONYM: Electrodiagnostic study, rectal electromyography.

AREA OF APPLICATION: Sphincter muscles.

CONTRAST: None.

DESCRIPTION: Pelvic floor sphincter electromyography, also known as rectal electromyography, is performed to measure electrical activity of the external urinary sphincter. This procedure, often done in conjunction with cystometry and voiding urethrography as part of a full urodynamic study, helps to diagnose neuromuscular dysfunction and incontinence.

INDICATIONS:

Evaluate neuromuscular dysfunction and incontinence

RESULT:

Normal findings in:

- Normal urinary and anal sphincter muscle function; increased electromyographic signals during the filling of the urinary bladder and at the conclusion of voiding; absence of signals during the actual voiding; no incontinence.

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Age-related decreases in electrical activity
- Medications such as muscle relaxants, cholinergics, and anticholinergics

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure is performed to measure electrical activity of the pelvic floor muscles.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure. Warn the patient the procedure may be uncomfortable, but an analgesic or sedative will be administered. Assure the patient the pain is minimal during the catheter insertion. Inform the patient the procedure is performed in a special laboratory by a health care provider (HCP) and takes about 30 min to complete.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ Assess for ability to comply with directions given for exercising during the test.
- ▶ Under medical direction, the patient should avoid muscle relaxants, cholinergics, and anticholinergics for 3 to 6 days before the test.
- ▶ Instruct the patient to refrain from smoking and drinking caffeine-containing beverages for 3 hr before the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluid, tobacco, and medication restrictions and pretesting preparations.
- ▶ Record baseline vital signs.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Place the patient in a supine position on the examining table and place a drape over the patient, exposing the perineal area.
- ▶ Ask the patient to remain very still and relaxed and to cooperate when instructed to contract muscles during the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Two skin electrodes are positioned slightly to the left and right of the perianal area and a grounding electrode is placed on the thigh.
- ▶ If needle electrodes are used, they are inserted into the muscle surrounding the urethra.
- ▶ Muscle activity signals are recorded as waves, which are interpreted for number and configurations in diagnosing urinary abnormalities.
- ▶ An indwelling urinary catheter is inserted, and the bulbocavernosus reflex is tested; the patient is instructed to cough while the catheter is gently pulled.
- ▶ Voluntary control is tested by requesting the patient to contract and relax the muscle. Electrical activity is recorded during this period of relaxation with the bladder empty.
- ▶ The bladder is filled with sterile water at a rate of 100 mL/min while the electrical activity during filling is recorded.
- ▶ The catheter is removed; the patient is then placed in a position to void and is asked to urinate and empty the full bladder. This voluntary urination is then recorded until completed. The complete procedure includes recordings of electrical signals before, during, and at the end of urination.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Instruct the patient to increase fluid intake unless contraindicated.
- ▶ If tested with needle electrodes, warn female patients to expect hematuria after the first voiding.
- ▶ Advise the patient to report symptoms of urethral irritation, such as dysuria, persistent or prolonged hematuria, and urinary frequency.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss

the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of

the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include CT pelvis, cystometry, cystoscopy, cystourethrography voiding, IVP, and US bladder.
- ◆ Refer to the Genitourinary and Musculoskeletal System tables in the back of the book for related tests by body system.

E

Electroneurography

SYNONYM/ACRONYM: Electrodiagnostic study, nerve conduction study, ENG.

AREA OF APPLICATION: Muscles.

CONTRAST: None.

DESCRIPTION: Electroneurography (ENG) is performed to identify peripheral nerve injury, to differentiate primary peripheral nerve pathology from muscular injury, and to monitor response of the nerve injury to treatment. A stimulus is applied through a surface electrode over a nerve. After a nerve is electrically stimulated proximally, the time for the impulse to travel to a second or distal site is measured. Because the conduction study of a nerve can vary from nerve to nerve, it is important to compare the results of the affected side to those of the contralateral side. The results of the stimulation

are shown on a monitor, but the actual velocity must be calculated by dividing the distance in meters between the stimulation point and the response point, by the time between the stimulus and response. Traumatic nerve transection, contusion, or neuropathy will usually cause maximal slowing of conduction velocity in the affected side compared with that in the normal side. A velocity greater than normal does not indicate a pathological condition. This test is usually performed in conjunction with electromyography in a combined test called *electromyoneurography*.

INDICATIONS:

Confirm diagnosis of peripheral nerve damage or trauma

RESULT:**Normal findings in:**

- No evidence of peripheral nerve injury or disease. Variable readings depend on the nerve being tested. For patients age 3 yr and older, the maximum conduction velocity is 40 to 80 msec; for infants and the elderly, the values are divided by 2.

Abnormal findings in:

- Carpal tunnel syndrome
- Diabetic neuropathy
- Guillain-Barré syndrome
- Herniated disk disease
- Muscular dystrophy
- Myasthenia gravis
- Poliomyelitis
- Tarsal tunnel syndrome
- Thoracic outlet syndrome

CRITICAL VALUES: N/A

INTERFERING FACTORS:**Factors that may impair the results of the examination:**

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Age-related decreases in electrical activity
- Poor electrode conduction or failure to obtain contralateral values for comparison

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient the procedure is performed to measure electrical activity of the muscles.

- ▶ Obtain a history of the patient's complaints or symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ▶ Obtain a history of the patient's neuromuscular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and inform the patient the procedure may be uncomfortable because of a mild electrical shock. Advise the patient that the electrical shock is brief and is not harmful. Inform the patient the procedure is performed in a special laboratory by a health care provider (HCP) and takes approximately 15 min to complete, but can take longer depending on the patient's condition.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Place the patient in a supine or sitting position, depending on the location of the muscle to be tested.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Shave the extremity in the area to be stimulated, and cleanse the skin thoroughly with alcohol pads.

- ▶ Apply electrode gel and place a recording electrode at a known distance from the stimulation point. Measure the distance between the stimulation point and the site of the recording electrode in centimeters.
- ▶ Place a reference electrode nearby on the skin surface.
- ▶ The nerve is electrically stimulated by a shock-emitter device; the time between nerve impulse and electrical contraction, measured in millisecond (distal latency), is shown on a monitor.
- ▶ The nerve is also electrically stimulated at a location proximal to the area of suspected injury or disease.
- ▶ The time required for the impulse to travel from the stimulation site to location of the muscle contraction (total latency) is recorded in millisecond.
- ▶ Calculate the conduction velocity. The conduction velocity is converted to meters per second (m/sec) and computed using the following equation:

$$\text{Conduction velocity (in m/sec)} = \frac{\text{[distance (in m)]}}{\text{[total latency - distal latency]}}$$
- ▶ If residual pain is noted after the procedure, instruct the patient to apply warm compresses and to take analgesics, as ordered.
- ▶ Instruct the patient to resume usual diet, medication, and activity, as directed by the HCP.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the procedure is complete, remove the electrodes and clean the skin where the electrodes were applied.
- ▶ Monitor electrode sites for inflammation.

RELATED MONOGRAPHS:

- ▶ Related tests include acetylcholine receptor antibody, biopsy muscle, CK, EMG, and evoked brain potentials (SER, VER).
- ▶ Refer to the Musculoskeletal System table in the back of the book for related tests by body system.

Eosinophil Count

SYNONYM/ACRONYM: Eos count, total eosinophil count.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Manual count using eosinophil stain and hemocytometer or automated analyzer)

Absolute count: 50 to 500/mm³

Relative percentage: 1% to 4%

DESCRIPTION: Eosinophils are white blood cells whose function is phagocytosis of antigen-antibody complexes and response to allergy-inducing substances and parasites. Eosinophils have granules that contain histamine used to kill foreign cells in the body. Eosinophils also contain proteolytic substances that damage parasitic worms. The binding of histamine to receptor sites on cells results in smooth muscle contraction in the bronchioles and upper respiratory tract, constriction of pulmonary vessels, increased mucus production, and secretion of acid by the cells that line the stomach. Eosinophil counts can increase to greater than 30% of normal in parasitic infections; however, a significant percentage of children with visceral larva migrans infestations have normal eosinophil counts.

INDICATIONS:

Assist in the diagnosis of conditions such as allergies, parasitic infections, drug reactions, collagen diseases, Hodgkin's disease, and myeloproliferative disorders

RESULT:

Increased in:

- *Eosinophils are released and migrate to inflammatory sites in response to numerous environmental, chemical/drug, or immune-mediated triggers. T-cells, mast cells, and macrophages release cytokines like interleukin-3 (IL3), interleukin-5 (IL5), granulocyte/macrophage colony stimulating factor, and chemokines like the eotaxins,*

which can result in the activation of eosinophils.

- Addison's disease (**Most commonly related to autoimmune destruction of adrenal glands**)
- Allergy
- Asthma
- Cancer
- Dermatitis
- Drug reactions
- Eczema
- Hay fever
- Hodgkin's disease
- Hypereosinophilic syndrome (rare and idiopathic)
- Löffler's syndrome (**Pulmonary eosinophilia due to allergic reaction or infection from a fungus or parasite**)
- Myeloproliferative disorders (**Related to abnormal changes in the bone marrow**)
- Parasitic infection (visceral larva migrans)
- Rheumatoid arthritis (**Possibly related to medications used in therapy**)
- Rhinitis
- Sarcoidosis
- Splenectomy
- Tuberculosis

Decreased in:

- Aplastic anemia (**Bone marrow failure**)
- Eclampsia (**Shift to the left; relative to significant production of neutrophils**)
- Infections (**Shift to the left; relative to significant production of neutrophils**)
- Stress (**Release of cortisol suppresses eosinophils**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Numerous drugs and substances can cause an increase in eosinophil levels as a result of an allergic response or hypersensitivity

reaction. These include acetophenazine, allopurinol, aminosalicic acid, ampicillin, butaperazine, capreomycin, carisoprodol, cephaloglycin, cephaloridine, cephalosporins, cephapirin, cephradine, chloramphenicol, clindamycin, cloxacillin, dapsone, epicillin, erythromycin, fluorides, gold, imipramine, iodides, kanamycin, mefenamic acid, methicillin, methyldopa, minocycline, nalidixic acid, niridazole, nitrofurans (including nitrofurantoin), NSAIDs, nystatin, oxamniquine, penicillin, penicillin G, procainamide, ristocetin, streptokinase, streptomycin, tetracycline, triamterene, tryptophan, and viomycin.

- Drugs that can cause a decrease in eosinophil levels include acetylsalicic acid, amphotericin B, corticotropin, desipramine, glucocorticoids, hydrocortisone, interferon, niacin, prednisone, and procainamide.
- Clotted specimens should be rejected for analysis.
- Specimens more than 4 hr old should be rejected for analysis.
- There is a diurnal variation in eosinophil counts. The count is lowest in the morning and continues to rise throughout the day until midnight. Therefore, serial measurements should be performed at the same time of day for purposes of continuity.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of conditions related to immune response, such as allergy or parasitic infection.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic, immune, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations*: Consideration should be given to diet if food allergies are present.

- ▶ Instruct the patient with an elevated eosinophil count to report any signs or symptoms of infection, such as fever.
- ▶ Instruct the patient with an elevated count to rest and take medications as prescribed, to increase fluid intake as appropriate, and to monitor temperature.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include allergen-specific immunoglobulin E, biopsy bone marrow, blood gases, complete blood count, culture stool, ESR, fecal analysis, hypersensitivity pneumonitis screen, IgE, lung perfusion scan, ova and parasites, plethysmography, and PFT.
- ▶ Refer to the Hematopoietic, Immune, and Respiratory System tables at the end of the book for related tests by body system.

Erythrocyte Protoporphyrin, Free

SYNONYM/ACRONYM: Free erythrocyte protoporphyrin (FEP).

SPECIMEN: Whole blood (1 mL) collected in lavender-top (EDTA) or green-top (heparin) tube.

REFERENCE VALUE: (Method: Fluorometry)

Conventional Units	SI Units (Conventional Units × 0.0178)
17–77 mcg/dL of packed cells	0.3–1.37 micromol/L of packed cells

DESCRIPTION: The free erythrocyte protoporphyrin test measures the concentration of protoporphyrin in red blood cells. Protoporphyrin comprises the predominant porphyrin in red blood cells, which combines with iron to form the heme portion of hemoglobin. Protoporphyrin converts to bilirubin, combines with albumin, and remains unconjugated in the circulation after hemoglobin breakdown. Increased amounts of protoporphyrin can be detected

in erythrocytes, urine, and stool in conditions interfering with heme synthesis. Protoporphyrin is an autosomal dominant disorder in which increased amounts of protoporphyrin are secreted and excreted; the disorder is thought to be the result of an enzyme deficiency. Protoporphyrin causes photosensitivity and may lead to cirrhosis of the liver and cholelithiasis as a result of protoporphyrin deposits.

INDICATIONS:

- Assist in the diagnosis of erythropoietic protoporphyrias
- Assist in the differential diagnosis of iron deficiency in pediatric patients
- Evaluate lead poisoning

RESULT:**Increased in:**

- Anemia of chronic disease
- Conditions with marked erythropoiesis (e.g., hemolytic anemias) **(Related to increased cell destruction)**
- Erythropoietic protoporphyria **(Related to abnormal increased secretion)**
- Iron-deficiency anemias **(Related to accumulation of protoporphyrin in the absence of available iron)**
- Lead poisoning **(Possibly related to inactivation of enzymes involved in iron binding or transfer)**
- Some sideroblastic anemias

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase erythrocyte protoporphyrin levels include barbiturates, chlorpropamide, oral contraceptives, sulfomethane, and tolbutamide.
- The test is unreliable in infants less than 6 mo of age.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to detect lead toxicity and to monitor chronic lead exposure. It is

also used to differentiate disorders in heme and globin production.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. Specimens should be protected from light.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor

progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count, hematocrit, complete blood count, hemoglobin, iron/TIBC, lead, and urine porphyrins.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Erythrocyte Sedimentation Rate

SYNONYM/ACRONYM: Sed rate, ESR.

SPECIMEN: Whole blood (5 mL) collected in a lavender-top (EDTA) tube for the modified Westergren method or gray-top (3.8% sodium citrate) tube for the original Westergren method.

REFERENCE VALUE: (Method: Westergren)

Age	Male	Female
Newborn	0–2 mm/hr	0–2 mm/hr
Less than 50 yr	0–15 mm/hr	0–25 mm/hr
50 yr and older	0–20 mm/hr	0–30 mm/hr

DESCRIPTION: The erythrocyte sedimentation rate (ESR) is a measure of the rate of sedimentation of red blood cells (RBCs) in an anticoagulated whole blood sample over a specified period of time. The basis of the ESR test is the alteration of blood proteins by inflammatory and necrotic processes that cause the RBCs to stick together, become heavier, and rapidly settle at the bottom of a vertically

held, calibrated tube over time. The most common promoter of rouleaux is an increase in circulating fibrinogen levels. In general, relatively little settling occurs in normal blood because normal RBCs do not form rouleaux (which increases their mass and rate of sedimentation) and would not stack together. The sedimentation rate is proportional to the size or mass of the falling RBCs and is inversely

proportional to plasma viscosity. The test is a nonspecific indicator of disease but is fairly sensitive and is frequently the earliest indicator of widespread inflammatory reaction due to infection or autoimmune disorders. Prolonged elevations are also present in malignant disease. The ESR can also be used to monitor the course of a disease and the effectiveness of therapy. The most commonly used method to measure the ESR is the Westergren (or modified Westergren) method.

INDICATIONS:

- Assist in the diagnosis of acute infection, such as tuberculosis or tissue necrosis
- Assist in the diagnosis of acute inflammatory processes
- Assist in the diagnosis of chronic infections
- Assist in the diagnosis of rheumatoid or autoimmune disorders
- Assist in the diagnosis of temporal arthritis and polymyalgia rheumatica
- Monitor inflammatory and malignant disease

RESULT:

Increased in:

- **Increased rouleaux formation is associated with increased levels of fibrinogen and/or production of cytokines and other acute phase reactant proteins in response to inflammation.**
- Acute myocardial infarction
- Anemia (**RBCs fall faster with increased plasma volume**)
- Carcinoma
- Cat scratch fever (*Bartonella henselae*)
- Collagen diseases, including systemic lupus erythematosus (SLE)
- Crohn's disease (**Due to anemia or related to acute phase reactant proteins**)

- Endocarditis
- Heavy metal poisoning (**Related to anemia affecting size and shape of RBCs**)
- Increased plasma protein level (**RBCs fall faster with increased plasma viscosity**)
- Infections (e.g., pneumonia, syphilis)
- Inflammatory diseases
- Lymphoma
- Lymphosarcoma
- Multiple myeloma (**RBCs fall faster with increased plasma viscosity**)
- Nephritis
- Pregnancy
- Pulmonary embolism
- Rheumatic fever
- Rheumatoid arthritis
- Subacute bacterial endocarditis
- Temporal arteritis
- Toxemia
- Tuberculosis
- Waldenström's macroglobulinemia (**RBCs fall faster with increased plasma viscosity**)

Normal findings in:

- Congestive heart failure
- Glucose-6-phosphate dehydrogenase deficiency
- Hemoglobin C disease
- Hypofibrinogenemia
- Polycythemia
- Sickle cell anemia
- Spherocytosis

Decreased in:

- Conditions resulting in high hemoglobin and RBC count
- Elevated blood glucose (**Hyperglycemia in older patients can induce production of cytokines responsible for the inflammatory response; hyperglycemia related to insulin resistance can cause hepatocytes to shift protein synthesis from albumin to production of acute phase reactant proteins**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Some drugs cause an SLE-like syndrome that results in a physiological increase in ESR. These include anticonvulsants, hydrazine derivatives, nitrofurantoin, procainamide, and quinidine. Other drugs that may cause an increased ESR include acetylsalicylic acid, cephalothin, cephapirin, cyclosporin A, dextran, and oral contraceptives.
- Drugs that may cause a decrease in ESR include aurothiomalate, corticotropin, cortisone, and quinine.
- Menstruation may cause falsely increased test results.
- Prolonged tourniquet constriction around the arm may cause hemoconcentration and falsely low values.
- The Westergren and modified Westergren methods are affected by heparin, which causes a false elevation in values.
- Bubbles in the Westergren tube or pipette, or tilting the measurement column more than 3° from vertical, will falsely increase the values.
- Movement or vibration of the surface on which the test is being conducted will affect the results.
- Inaccurate timing will invalidate test results.
- Specimens that are clotted, hemolyzed, or insufficient in volume should be rejected for analysis.
- The test should be performed within 4 hr of collection when the specimen has been stored at room temperature; delays in testing may result in decreased values. If a delay in testing is anticipated, refrigerate the sample at 2°C to 4°C; stability at refrigerated temperature is reported to be extended up to 12 hr. Refrigerated specimens should be brought to room temperature before testing.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is a nonspecific indicator of inflammation.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of infectious, autoimmune, or neoplastic diseases.
- ▶ Obtain a history of the patient's hematopoietic, immune, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a 5-mL gray-top (sodium citrate) tube if the Westergren method will be used.

Collect the specimen in a 5-mL purple-top (EDTA) tube if the modified Westergren method will be used.

- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antibodies, anticyclic citrullinated peptide, ANA, arthroscopy, arthrogram, blood pool imaging, BMD, bone scan, complete blood count, complete blood count, hematocrit, complete blood count, hemoglobin, complete blood count, RBC indices, complete blood count, RBC morphology, CT cardiac scoring, copper, CRP, D-dimer, exercise stress test, fibrinogen, glucose, iron, lead, MRI musculoskeletal, microorganism-specific serologies and related cultures, myocardial perfusion heart scan, radiography bone, RF, synovial fluid analysis, and troponin.
- Refer to the Cardiovascular, Hematopoietic, Immune, and Respiratory System tables at the end of the book for related tests by body system.

Erythropoietin

SYNONYM/ACRONYM: EPO.

SPECIMEN: Serum (2 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay).

Conventional Units

5–36 milli-international units/mL

SI Units (Conventional Units × 1)

5–36 international units/L

DESCRIPTION: Erythropoietin (EPO) is a glycoprotein produced mainly by the kidney. Its function is to stimulate the bone marrow to make red blood cells (RBCs). EPO levels fall after removal of the kidney but do not disappear completely. It is thought that small

amounts of EPO may be produced by the liver. Erythropoiesis is regulated by EPO and tissue Po_2 . When Po_2 is normal, EPO levels decrease; when Po_2 falls, EPO secretion occurs and EPO levels increase.

INDICATIONS:

- Assist in assessment of anemia of end-stage renal disease
- Assist in the diagnosis of EPO-producing tumors
- Evaluate the presence of rare anemias
- Monitor patients receiving EPO therapy

RESULT:**Increased in:**

- After moderate bleeding in an otherwise healthy patient (**Loss of RBC stimulates production**)
- Anemias (**Low RBC count stimulates production**)
- Hepatoma (**EPO-producing tumors**)
- Kidney transplant rejection (**15% of cases respond with an exaggerated secretion of EPO and a transient post-transplantation erythrocytosis**)
- Nephroblastoma (**EPO-producing tumors**)
- Pheochromocytoma (**EPO-producing tumors**)
- Polycystic kidney disease (**EPO-producing tumors or cysts**)
- Pregnancy (**Anemia of pregnancy stimulates production**)
- Secondary polycythemia where low oxygen levels stimulate production (**high-altitude hypoxia, chronic obstructive pulmonary disease, pulmonary fibrosis**)

Decreased in:

- Chemotherapy (**Therapy can be toxic to the kidney**)
- Primary polycythemia (**Feedback loop response to elevated RBC count**)
- Renal failure (**Decreased production and excessive loss through excretion by damaged kidneys**)

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase EPO levels include anabolic steroids.
- Drugs that may decrease EPO levels include amphotericin B, cisplatin, enalapril, estrogens, and theophylline.
- Blood transfusions may also decrease EPO levels.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used in the evaluation of anemias.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further

testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, BUN, complete blood count, complete blood count, hematocrit, complete blood count, hemoglobin, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology and inclusions, CT renal, creatinine, creatinine clearance, ferritin, iron/TIBC, microalbumin, retrograde ureteropyelography, US kidney, and vitamin B₁₂.
- ▶ Refer to the Hematopoietic and Genitourinary System tables at the end of the book for related tests by body system.

Esophageal Manometry

SYNONYM/ACRONYM: Esophageal function study, esophageal acid study (Tuttle test), acid reflux test, Bernstein test (acid perfusion), esophageal motility study.

AREA OF APPLICATION: Esophagus.

CONTRAST: Done with or without noniodinated contrast medium.

DESCRIPTION: Esophageal manometry (EM) consists of a group of invasive studies performed to assist in diagnosing abnormalities of esophageal muscle function and esophageal structure. These studies measure esophageal pressure, the effects

of gastric acid in the esophagus, lower esophageal sphincter pressure, and motility patterns that result during swallowing. EM can be used to document and quantify gastroesophageal reflux (GER). It is indicated when a patient is experiencing

difficulty swallowing, heartburn, regurgitation, or vomiting; or has chest pain for which no diagnosis has been found. Tests performed in combination with EM include the acid reflux, acid clearing, and acid perfusion (Bernstein) tests.

INDICATIONS:

- Aid in the diagnosis of achalasia, evidenced by increased pressure in EM
- Aid in the diagnosis of chaliasia in children, evidenced by decreased pressure in EM
- Aid in the diagnosis of esophageal scleroderma, evidenced by decreased pressure in EM
- Aid in the diagnosis of esophagitis, evidenced by decreased motility
- Aid in the diagnosis of GER, evidenced by low pressure in EM, decreased pH in acidity test, and pain in acid reflux and perfusion tests
- Differentiate between esophagitis or cardiac condition as the cause of epigastric pain
- Evaluate pyrosis and dysphagia to determine if the cause is GER or esophagitis

RESULT:

Normal findings in:

- Acid clearing: fewer than 10 swallows
- Acid perfusion: no GER
- Acid reflux: no regurgitation into the esophagus
- Bernstein test: negative
- Esophageal secretions: pH 5 to 6
- Esophageal sphincter pressure: 10 to 20 mm Hg

Abnormal findings in:

- Achalasia (sphincter pressure of 50 mm Hg)
- Chaliasia
- Esophageal scleroderma
- Esophagitis

- GER (sphincter pressure of 0 to 5 mm Hg, pH of 1 to 3)
- Hiatal hernia
- Progressive systemic sclerosis (scleroderma)
- Spasms

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with unstable cardiopulmonary status, blood coagulation defects, recent gastrointestinal surgery, esophageal varices, or bleeding

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Administration of medications (e.g., sedatives, antacids, anticholinergics, cholinergics, corticosteroids) that can change pH or relax the sphincter muscle, causing inaccurate results

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the esophagus.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, and contrast mediums.

- ▶ Obtain a history of the patient's respiratory and gastrointestinal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent barium or other radiological contrast procedures. Ensure that barium studies were performed more than 4 days before the EM.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort and gagging when the scope is inserted, but there are no complications resulting from the procedure and the throat will be anesthetized with a spray or swab. Inform the patient that he or she will not be able to speak during the procedure, but that breathing will not be affected. Inform the patient that the procedure is performed in an endoscopy suite by a health care provider (HCP) under local anesthesia, and takes approximately 30 to 45 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be started to allow for the infusion of a sedative or IV fluids.
- ▶ Instruct the patient to remove dentures and eyewear.
- ▶ Under medical direction, the patient should withhold medications for 24 hr before the study; special arrangements may be necessary for diabetic patients.
- ▶ Instruct the patient to fast and restrict fluids for 6 to 8 hr prior to the procedure. Protocols may vary from facility to facility.

- ▶ Obtain and record baseline vital signs.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluids, and medication restrictions and pretesting preparations for at least 6 to 8 hr prior to the procedure.
- ▶ Ensure the patient has removed dentures and eyewear prior to the procedure.
- ▶ Avoid using morphine sulfate in patients with asthma or other pulmonary disease. This drug can further exacerbate bronchospasms and respiratory impairment.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Insert an IV line and inject ordered sedation.
- ▶ Spray or swab the oropharynx with a topical local anesthetic.
- ▶ Provide an emesis basin for the increased saliva and encourage the patient to spit out saliva since the gag reflex may be impaired.
- ▶ Monitor the patient for complications related to the procedure (e.g., aspiration of stomach contents into the lungs, dyspnea, tachypnea, adventitious sounds).
- ▶ Suction the mouth, pharynx, and trachea, and administer oxygen as ordered.

Esophageal Manometry:

- ▶ One or more small tubes are inserted through the nose into the esophagus and stomach.
- ▶ A small transducer is attached to the ends of the tubes to measure

lower esophageal sphincter pressure, intraluminal pressures, and regularity and duration of peristaltic contractions.

- ▶ Instruct the patient to swallow small amounts of water or flavored gelatin.

Esophageal Acid and Clearing (Tuttle Test):

- ▶ With the tube in place, a pH electrode probe is inserted into the esophagus with Valsalva maneuvers performed to stimulate reflux of stomach contents into the esophagus.
- ▶ If acid reflux is absent, 100 mL of 0.1% hydrochloric acid is instilled into the stomach during a 3-min period, and the pH measurement is repeated.
- ▶ To determine acid clearing, hydrochloric acid is instilled into the esophagus and the patient is asked to swallow while the probe measures the pH.

Acid Perfusion (Bernstein Test):

- ▶ A catheter is inserted through the nose into the esophagus and the patient is asked to inform the HCP when pain is experienced.
- ▶ Normal saline solution is allowed to drip into the catheter at about 10 mL/min. Then hydrochloric acid is allowed to drip into the catheter.
- ▶ Pain experienced when the hydrochloric acid is instilled determines the presence of an esophageal abnormality. If no pain is experienced, symptoms are the result of some other condition.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Monitor the patient for signs of respiratory depression (less than 15 respirations/min) every 15 min for 2 hr. Resuscitation equipment should be available.
- ▶ Observe the patient for indications of perforation: painful swallowing with neck movement, substernal pain with respiration, shoulder pain, dyspnea,

abdominal or back pain, cyanosis, and fever.

- ▶ Instruct the patient not to eat or drink until the gag reflex returns and then to eat lightly for 12 to 24 hr.
- ▶ Instruct the patient to resume usual activity, medication, and diet 24 hr after the examination or as tolerated, as directed by the HCP.
- ▶ Inform the patient to expect some throat soreness and possible hoarseness. Advise the patient to use warm gargles, lozenges, or ice packs to the neck and to drink cool fluids to alleviate throat discomfort.
- ▶ Emphasize that any severe pain, fever, difficulty breathing, or expectoration of blood must be reported to the HCP immediately.
- ▶ Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ANA, barium swallow, biopsy skin, capsule endoscopy, chest x-ray, CT thoracic, esophagogastroduodenoscopy, fecal analysis, gastric emptying scan, GER scan, and upper GI series, lung perfusion scan, and mediastinoscopy.
- ▶ Refer to the Gastrointestinal and Respiratory System tables at the back of the book for related tests by body system.

Esophagogastroduodenoscopy

SYNONYM/ACRONYM: Esophagoscopy, gastroscopy, upper GI endoscopy, EGD.

AREA OF APPLICATION: Esophagus, stomach, and upper duodenum.

CONTRAST: Done without contrast.

E

DESCRIPTION: Esophagogastroduodenoscopy (EGD) allows direct visualization of the upper gastrointestinal (GI) tract mucosa, which includes the esophagus, stomach, and upper portion of the duodenum, by means of a flexible endoscope. The standard flexible fiberoptic endoscope contains three channels that allow passage of the instruments needed to perform therapeutic or diagnostic procedures, such as biopsies or cytology washings. The endoscope, a multichannel instrument, allows visualization of the GI tract linings, insufflation of air, aspiration of fluid, removal of foreign bodies by suction or by snare or forceps, and passage of a laser beam for obliteration of abnormal tissue or control of bleeding. Direct visualization yields greater diagnostic data than is possible through radiological procedures, and therefore EGD is rapidly replacing upper GI series as the diagnostic procedure of choice.

INDICATIONS:

- Assist in differentiating between benign and neoplastic tumors
- Detect gastric or duodenal ulcers
- Detect upper GI inflammatory disease
- Determine the presence and location of acute upper GI bleeding
- Evaluate the extent of esophageal injury after ingestion of chemicals
- Evaluate stomach or duodenum after surgical procedures
- Evaluate suspected gastric outlet obstruction
- Identify tissue abnormalities and obtain biopsy specimens
- Investigate the cause of dysphagia, dyspepsia, and epigastric pain

RESULT:

Normal findings in:

- Esophageal mucosa is normally yellow-pink. At about 9 in. from the incisor teeth, a pulsation indicates the location of the aortic arch. The gastric mucosa is orange-red and contains rugae. The proximal duodenum is reddish and contains a few longitudinal folds, whereas the distal duodenum has circular folds lined with villi. No abnormal structures or functions are observed in the esophagus, stomach, or duodenum.

Abnormal findings in:

- Acute and chronic gastric and duodenal ulcers
- Diverticular disease
- Duodenitis
- Esophageal varices
- Esophageal or pyloric stenosis
- Esophagitis or strictures
- Gastritis
- Hiatal hernia
- Mallory-Weiss syndrome
- Tumors (benign or malignant)

CRITICAL VALUES:

- Presence and location of acute GI bleed

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who have had surgery involving the stomach or duodenum, which can make locating the duodenal papilla difficult
- Patients with a bleeding disorder
- Patients with unstable cardiopulmonary status, blood coagulation defects, or cholangitis, unless the patient received prophylactic antibiotic therapy before the test (otherwise the examination must be rescheduled)
- Patients with unstable cardiopulmonary status, blood coagulation defects, known aortic arch aneurysm, large esophageal Zenker's diverticulum, recent GI surgery, esophageal varices, or known esophageal perforation.

Factors that may impair clear imaging:

- Gas or food in the GI tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses the esophagus and upper GI tract.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ♦ Obtain a history of the patient's GI system, symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent barium or other radiological contrast procedures ordered. Ensure that barium studies are performed after this study.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ♦ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort, but that the throat will be anesthetized with a spray or swab. Inform the patient that he or she will not be able to speak during the procedure, but that breathing will not be affected. Inform the patient that the procedure is performed in a GI lab or radiology department, usually by a health care provider (HCP) and support staff, and takes approximately 30 to 60 min.
- ♦ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ Explain that an IV line may be started to allow for the infusion of a sedative or IV fluids.
- ▶ Inform the patient that a laxative and cleansing enema may be needed the day before the procedure, with cleansing enemas on the morning of the procedure, depending on the institution's policy.
- ▶ Inform the patient that dentures and eyewear will be removed before the test.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary and medication restrictions and pretesting preparations for at least 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Assess for completion of bowel preparation according to the institution's procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
- ▶ Obtain and record baseline vital signs.
- ▶ Start an IV line and administer ordered sedation.
- ▶ Spray or swab the oropharynx with a topical local anesthetic.
- ▶ Provide an emesis basin for the increased saliva and encourage the

- ▶ patient to spit out the saliva because the gag reflex may be impaired.
- ▶ Place the patient on an examination table in the left lateral decubitus position with the neck slightly flexed forward.
- ▶ The endoscope is passed through the mouth with a dental suction device in place to drain secretions. A side-viewing flexible, fiberoptic endoscope is advanced, and visualization of the GI tract is started.
- ▶ Air is insufflated to distend the upper GI tract, as needed. Biopsy specimens are obtained and/or endoscopic surgery is performed.
- ▶ Promptly transport the specimens to the laboratory for processing and analysis.
- ▶ At the end of the procedure, excess air and secretions are aspirated through the scope and the endoscope is removed.
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe the patient for indications of esophageal perforation (i.e., painful swallowing with neck movement, substernal pain with respiration, shoulder pain or dyspnea, abdominal or back pain, cyanosis, or fever).
- ▶ Do not allow the patient to eat or drink until the gag reflex returns; then allow the patient to eat lightly for 12 to 24 hr.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered by the HCP. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Instruct the patient to resume usual activity and diet in 24 hr or as tolerated after the examination, as directed by the HCP.
- ▶ Inform the patient that he or she may experience some throat soreness and hoarseness. Instruct patient to treat throat discomfort with lozenges and warm gargles when the gag reflex returns.

- Inform the patient that any belching, bloating, or flatulence is the result of air insufflation and is temporary.
- Instruct the patient that any severe pain, fever, difficulty breathing, or expectoration of blood must be immediately reported to the HCP.
- Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be

needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include barium enema, barium swallow, capsule endoscopy, colonoscopy, CT abdomen, esophageal manometry, fecal analysis, gastric acid emptying scan, gastric acid stimulation test, gastrin stimulation, GI blood loss scan, H. pylori, MRI abdomen, proctosigmoidoscopy, US pelvis, upper GI series.
- Refer to the Gastrointestinal System table in the back of the book for related tests by body system.

Estradiol

SYNONYM/ACRONYM: E2.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Immunoassay)

Age	Conventional Units	SI Units (Conventional Units × 3.67)
6 mo–10 yr		
Male and Female	Less than 15 pg/mL	Less than 55 pmol/L
11–15 yr		
Male	Less than 40 pg/mL	Less than 147 pmol/L
Female	10–300 pg/mL	37–1100 pmol/L
Adult male	10–50 pg/mL	37–184 pmol/L
Adult female		
Early follicular phase	20–150 pg/mL	73–551 pmol/L
Late follicular phase	40–350 pg/mL	147–1285 pmol/L
Midcycle peak	150–750 pg/mL	551–2753 pmol/L
Luteal phase	30–450 pg/mL	110–1652 pmol/L
Postmenopause	Less than 20 pg/mL	Less than 73 pmol/L

RESULT:**Increased in:**

- Adrenal tumors (*Related to over-production by tumor cells*)
- Estrogen-producing tumors
- Feminization in children (*Related to increased production*)
- Gynecomastia (*Newborns may demonstrate swelling of breast tissue in response to maternal estrogens; somewhat common and transient in pubescent males*)
- Hepatic cirrhosis (*Accumulation occurs due to lack of liver function*)
- Hyperthyroidism (*Related to primary increases in estrogen*

or in response to increased levels of sex hormone binding globulin)

Decreased in:

- Ovarian failure (*Resulting in lack of estrogen synthesis*)
- Primary and secondary hypogonadism (*Related to lack of estrogen synthesis*)
- Turner's syndrome (*Genetic abnormality in females where there is only one X chromosome, resulting in varying degrees of underdeveloped sexual characteristics*)

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Evoked Brain Potentials

SYNONYM/ACRONYM: EP studies, brainstem auditory evoked potentials (BAEP), brainstem auditory evoked responses (BAER).

AREA OF APPLICATION: Brain.

CONTRAST: None.

DESCRIPTION: Evoked brain potentials, also known as evoked potential (EP) responses, are electrophysiological studies performed to measure the brain's electrical responses to various visual, auditory, and somatosensory stimuli. EP studies help diagnose lesions of the nervous system by evaluating the integrity of the visual, somatosensory, and auditory nerve pathways. Three response types are mea-

sured: visual evoked response (VER), auditory brainstem response (ABR), and somatosensory evoked response (SER). The stimuli activate the nerve tracts that connect the stimulated (receptor) area with the cortical (visual and somatosensory) or midbrain (auditory) sensory area. A number of stimuli are given and then responses are electronically displayed in waveforms, recorded, and

computer analyzed. Abnormalities are determined by a delay in time, measured in milliseconds, between the stimulus and the response. This is known as *increased latency*. VER provides information about visual pathway function to identify lesions of the optic nerves, optic tracts, and demyelinating diseases such as multiple sclerosis. ABR provides information about auditory pathways to identify hearing loss and lesions of the brainstem. SER provides information about the somatosensory pathways to identify lesions at various levels of the central nervous system (spinal cord and brain) and peripheral nerve disease. EP studies are especially useful in patients with problems and those unable to speak or respond to instructions during the test, because these studies do not require voluntary cooperation or participation in the activity. This allows collection of objective diagnostic information about visual or auditory disorders affecting infants and children, and allows differentiation between organic brain and psychological disorders in adults. EP studies are also used to monitor the progression of or the effectiveness of treatment for deteriorating neurological diseases such as multiple sclerosis.

INDICATIONS:

VER (potentials):

- Detect cryptic or past retrobulbar neuritis
- Detect lesions of the eye or optic nerves

- Detect neurological disorders such as multiple sclerosis, Parkinson's disease, and Huntington's chorea
- Evaluate binocularity in infants
- Evaluate optic pathway lesions and visual cortex defects

ABR (potentials):

- Detect abnormalities or lesions in the brainstem or auditory nerve areas
- Detect brainstem tumors and acoustic neuromas
- Screen or evaluate neonates, infants, children, and adults for auditory problems
- EP studies may be indicated when a child falls below growth chart norms

SER (potentials):

- Detect multiple sclerosis and Guillain-Barré syndrome
- Detect sensorimotor neuropathies and cervical pathology
- Evaluate spinal cord and brain injury and function
- Monitor sensory potentials to determine spinal cord function during a surgical procedure or medical regimen

ERP (potentials):

- Detect suspected psychosis or dementia
- Differentiate between organic brain disorder and cognitive function abnormality

RESULT:

Normal findings in:

VER and ABR: Normal latency in recorded cortical and brainstem waveforms depending on age, gender, and stature

ERP: Normal recognition and attention span

SER: No loss of consciousness or presence of weakness

Abnormal findings in:

- **VER (potentials):**
P100 latencies (extended) confined to one eye suggest a lesion anterior to the optic chiasm.
Bilateral abnormal P100 latencies indicate multiple sclerosis, optic neuritis, retinopathies, spinocerebellar degeneration, sarcoidosis, Parkinson's disease, adrenoleukodystrophy, Huntington's chorea, or amblyopias.
- **ABR (potentials):**
Normal response at high intensities; wave V may occur slightly later.
Earlier wave distortions suggest cochlear lesion.
Absent or late waves at high intensities; increased amplitude of wave V suggests retrocochlear lesion.
- **SER (potentials):**
Abnormal upper limb latencies suggest cervical spondylosis or intracerebral lesions.
Abnormal lower limb latencies suggest peripheral nerve root disease such as Guillain-Barré syndrome, multiple sclerosis, transverse myelitis, or traumatic spinal cord injuries.

CRITICAL VALUES: N/A**INTERFERING FACTORS:****Factors that may impair the results of the examination:**

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status (*Note:* significant behavioral problems may limit the ability to complete the test).
- Improper placement of electrodes
- Patient stress, which can affect brain chemistry, thus making it difficult to distinguish whether the results are due to the patient's emotional reaction or to organic pathology

- Extremely poor visual acuity, which can hinder accurate determination of VER
- Severe hearing loss, which can interfere with accurate determination of ABR

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient this procedure measures electrical activity in the nervous system.
- ▶ Obtain a history of the patient's complaints or symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ▶ Obtain a history of the patient's neuromuscular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that the procedure is painless and harmless. Inform the patient that the procedure is performed in a special laboratory by a health care provider (HCP) and takes approximately 30 min to 2 hr, depending on the type of studies required.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to clean the hair and to refrain from using hair sprays, creams, or solutions before the test.

- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient is able to relax; report any extreme anxiety or restlessness.
- ▶ Ensure that hair is clean and free of hair sprays, creams, or solutions.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.

Visual Evoked Potentials:

- ▶ Place the patient in a comfortable position about 1 m from the stimulation source. Attach electrodes to the occipital and vertex lobe areas and a reference electrode to the ear. A light-emitting stimulation or a checkerboard pattern is projected on a screen at a regulated speed. This procedure is done for each eye (with the opposite eye covered) as the patient looks at a dot on the screen without any change in the gaze while the stimuli are delivered. A computer interprets the brain's responses to the stimuli and records them in waveforms.

Auditory Evoked Potentials:

- ▶ Place the patient in a comfortable position, and place the electrodes on the scalp at the vertex lobe area and on each earlobe. Earphones are placed on the patient's ears, and a clicking noise stimulus is delivered into one ear while a continuous tone is delivered to the opposite ear. Responses to the stimuli are recorded as waveforms for analysis.

Somatosensory Evoked Potentials:

- ▶ Place the patient in a comfortable position, and place the electrodes at the nerve sites of the wrist, knee, and ankle and on the scalp at the sensory cortex of the hemisphere on the opposite side (the electrode that picks up the response and delivers it to the recorder). Additional electrodes can be positioned at the cervical or lumbar vertebrae for upper or lower limb stimulation. The rate at which the electric shock stimulus is delivered to the nerve electrodes and travels to the brain is measured, computer analyzed, and recorded in waveforms for analysis. Both sides of the area being examined can be tested by switching the electrodes and repeating the procedure.

Event-Related Potentials:

- ▶ Place the patient in a sitting position in a chair in a quiet room. Earphones are placed on the patient's ears and auditory cues administered. The patient is asked to push a button when the tones are recognized. Flashes of light are also used as visual cues, with the client pushing a button when cues are noted. Results are compared to normal EP waveforms for correct, incorrect, or absent responses.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the procedure is complete, remove the electrodes and clean the skin where the electrodes were applied.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or

address any concerns voiced by the patient or family.

- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include acetylcholine receptor antibody, Alzheimer disease markers, biopsy muscle, CSF analysis, CT brain, CK, EEG, ENG, MRI brain, plethysmography, and PET brain.
- Refer to the Musculoskeletal System table in the back of the book for related tests by body system.

E

Exercise Stress Test

SYNONYM/ACRONYM: Exercise electrocardiogram (ECG, EKG), graded exercise tolerance test, stress testing, treadmill test.

AREA OF APPLICATION: Heart.

CONTRAST: None.

DESCRIPTION: The exercise stress test is a noninvasive study to measure cardiac function during physical stress. Exercise electrocardiography is primarily useful in determining the extent of coronary artery occlusion by the heart's ability to meet the need for additional oxygen in response to the stress of exercising in a safe environment. The patient exercises on a treadmill or pedals a stationary bicycle to increase the heart rate to 80% to 90% of maximal heart rate determined by age and gender, known as the *target heart rate*. Every 2 to 3 min the speed and/or grade of the treadmill is increased to yield an increment of stress. The patient's electrocardiogram

(ECG) and blood pressure are monitored during the test. The test proceeds until the patient reaches the target heart rate or experiences chest pain or fatigue. The risks involved in the procedure are possible myocardial infarction (1 in 500) and death (1 in 10,000) in patients experiencing frequent angina episodes before the test. Although useful, this procedure is not as accurate as cardiac nuclear scans for diagnosing coronary artery disease (CAD).

For patients unable to complete the test, pharmacological stress testing can be done. Medications used to pharmacologically exercise the patient's heart include vasodilators such

as dipyridamole and adenosine or dobutamine (which stimulates heart rate and pumping force). The patient's electrocardiogram (ECG) and blood pressure are monitored during the test. The test proceeds until the stimulated exercise portion when a radiotracer, such as technetium-99m or sestamibi, is injected. Pictures are taken by a gamma camera during the stimulated portion and compared with images taken at rest.

INDICATIONS:

- Detect dysrhythmias during exercising, as evidenced by ECG changes
- Detect peripheral arterial occlusive disease (intermittent claudication), as evidenced by leg pain or cramping during exercising
- Determine exercise-induced hypertension
- Evaluate cardiac function after myocardial infarction or cardiac surgery to determine safe exercise levels for cardiac rehabilitation as well as work limitations
- Evaluate effectiveness of medication regimens, such as antianginals or antiarrhythmics
- Evaluate suspected CAD in the presence of chest pain and other symptoms
- Screen for CAD in the absence of pain and other symptoms in patients at risk

RESULT:

Normal findings in:

- Normal heart rate during physical exercise. Heart rate and systolic blood pressure rise in direct proportion to workload and to metabolic oxygen demand, which is based on age and exercise

protocol. Maximal heart rate for adults is normally 150 to 200 beats/min.

Abnormal findings in:

- Activity intolerance related to oxygen supply and demand imbalance
- Bradycardia
- CAD
- Chest pain related to ischemia or inflammation
- Decreased cardiac output
- Dysrhythmias
- Hypertension
- Peripheral arterial occlusive disease
- S-T segment depression of 1 mm (considered a positive test), indicating myocardial ischemia
- Tachycardia

CRITICAL VALUES: N/A

INTERFERING FACTORS:

The following factors may impair interpretation of examination results because they create an artificial state that makes it difficult to determine true physiological function:

- Anxiety or panic attack
- Drugs such as β -blockers, cardiac glycosides, calcium channel blockers, coronary vasodilators, and barbiturates
- High food intake or smoking before testing
- Hypertension, hypoxia, left bundle branch block, and ventricular hypertrophy
- Improper electrode placement
- Potassium or calcium imbalance
- Viagra should not be taken in combination with nitroglycerin or other nitrates 24 hr prior to the procedure as it may result in a dangerously low blood pressure
- Wolff-Parkinson-White syndrome (anomalous atrioventricular excitation)

**NURSING IMPLICATIONS
AND PROCEDURE****PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test assesses the heart's ability to respond to an increasing workload.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Inquire if the patient has had any chest pain within the past 48 hr, or has a history of anginal attacks; if either of these have occurred, inform the health care provider (HCP) immediately because the stress test may be too risky and should be rescheduled in 4 to 6 wk.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some discomfort may be experienced during the stimulated portion of the test. Inform the patient that the procedure is performed in a special department by a HCP specializing in this procedure and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Record a baseline 12-lead ECG and vital signs.
- ▶ Instruct the patient to wear comfortable shoes and clothing for the exercise.
- ▶ Instruct the patient to fast, restrict fluids, and avoid tobacco products for 4 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary and tobacco restrictions for at least 4 hr prior to the procedure.
- ▶ An IV access may be established for emergency use.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place electrodes in appropriate positions on the patient and connect a blood pressure cuff to a monitoring device. If the patient's oxygen consumption is to be continuously monitored, connect the patient to a machine via a mouthpiece or to a pulse oximeter via a finger lead.
- ▶ Instruct the patient to walk on a treadmill (most commonly used) and use the handrails to maintain balance or to peddle a bicycle. As stress is increased, inform the patient to report any symptoms, such as chest or leg pain, dyspnea, or fatigue.
- ▶ Turn the treadmill on at a slow speed, and increase in speed and elevation to raise the patient's heart rate. Increase the stress until the patient's predicted target heart rate is reached.
- ▶ Instruct the patient to report symptoms such as dizziness, sweating, breathlessness, or nausea, which can be normal, as speed increases. The test is terminated if pain or fatigue is severe; maximum heart rate under stress is attained; signs of ischemia are present; maximum effort has been achieved; or dyspnea, hypertension (systolic blood pressure greater than 200 mm Hg, diastolic blood pressure greater than 110 mm Hg, or both), tachycardia (greater than 200 beats/min minus person's age), new dysrhythmias, chest pain that begins or worsens, faintness, extreme dizziness, or confusion develops.
- ▶ After the exercise period, allow a 3- to 15-min rest period with the patient in a sitting position. During this period, the ECG, blood pressure, and heart rate monitoring is continued.

- Remove the electrodes and cleanse the skin of any remaining gel or ECG electrode adhesive.

POST-TEST:

- A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume usual activity, as directed by the HCP.
- Instruct the patient to contact the HCP to report any anginal pain or other discomforts experienced after the test.
- Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing

may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, atrial natriuretic peptide, BNP, blood gases, blood pool imaging, calcium, chest x-ray, cholesterol (total, HDL, LDL), CT cardiac scoring, CT thorax, CRP, CK and isoenzymes, echocardiography, echocardiography transesophageal, electrocardiogram, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isos, lipoprotein electrophoresis, lung perfusion scan, magnesium, MRI chest, MI infarct scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, pulse oximetry, sodium, triglycerides, and troponin.
- Refer to the Cardiovascular System table at the back of the book for related tests by body system.

FDG-PET Scan

SYNONYM/ACRONYM: Fluorodeoxyglucose (FDG)-positron emission tomography (PET).

AREA OF APPLICATION: Abdomen, brain, breast, heart, pelvis

CONTRAST: IV radioactive material fluorodeoxyglucose (FDG).

DESCRIPTION: Fluorine-18, in the form of fluorodeoxyglucose (FDG), is one of the more commonly used radionuclides. FDG is a glucose analogue, and because every cell uses glucose, the metabolic activity occurring in neurological conditions can be measured. There is little localization of FDG in normal tissue, allowing rapid detection of abnormal disease states. The brain uses oxygen and glucose almost exclusively to meet its energy needs, and therefore the brain's metabolism has been studied widely with positron emission tomography (PET). The role of this procedure is to detect metabolically active malignant lesions. FDG-PET scan may also be used to stage and monitor the response to the malignant disease.

PET combines the biochemical properties of nuclear medicine with the accuracy of computed tomography (CT). PET uses positron emissions from specific radionuclides (oxygen, nitrogen, carbon, and fluorine) to produce detailed functional images within the body. The positron radiopharmaceuticals generally have short half-lives, ranging from a few seconds to a few hours, and therefore they must be produced in a cyclotron located near where the test is being done. The PET scanner translates the emissions from the radioactivity as the positron combines with the negative

electrons from the tissues and forms gamma rays that can be detected by the scanner. This information is transmitted to the computer, which determines the location and its distribution and translates the emissions as color-coded images for viewing, quantitative measurements, activity changes in relation to time, and three-dimensional computer-aided analysis.

The expense of the study and the limited availability of radiopharmaceuticals limit the use of PET, even though it is more sensitive than traditional nuclear scanning and single-photon emission computed tomography. Changes in reimbursement and the advent of mobile technology have increased the availability of this procedure in the community setting.

INDICATIONS:

- Detect Parkinson's disease and Huntington's disease, as evidenced by decreased metabolism
- Determine physiological changes in psychosis and schizophrenia
- Evaluate Alzheimer's disease and differentiate it from other causes of dementia, as evidenced by decreased cerebral flow and metabolism
- Evaluate coronary artery disease (CAD), as evidenced by decreased myocardial blood flow and myocardial perfusion

- Evaluate myocardial viability, as evidenced by low glucose metabolism
- Evaluate tumors preoperatively and postoperatively and determine grade, stage, and appropriate treatment or procedure
- Identify cerebrovascular accident or aneurysm, as evidenced by decreased blood flow and oxygen use
- Identify focal seizures, as evidenced by decreased metabolism between seizures

RESULT:

Normal findings in:

- Normal patterns of tissue metabolism, blood flow, and radionuclide distribution

Abnormal findings in:

- Alzheimer's disease
- Brain trauma
- Breast cancer
- Colorectal cancer
- CAD
- Epilepsy
- Heart muscle dysfunction
- Huntington's disease
- Infections
- Lung cancer
- Lymphoma
- Melanoma
- Metastatic disease
- Myeloma
- Ovarian cancer
- Pancreatic cancer
- Parkinson's disease

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Drugs that alter glucose metabolism, such as tranquilizers, sedatives, or insulin, because hypoglycemia can alter PET results
- The use of alcohol, tobacco, or caffeine-containing drinks at least 24 hr before the study, because the effects of these substances, make it difficult to evaluate the patient's true physiological state (e.g., alcohol is a vasoconstrictor and would decrease blood flow to the target organ)
- Excessive exercise in the preceding 3 days, which can cause factitious uptake of the contrast material in the musculature
- Excessive anxiety may affect valuation of brain function
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

**NURSING IMPLICATIONS
AND PROCEDURE****PRETEST:**

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure helps assess blood flow to and tissue metabolism in the abdomen, brain, breast, heart, and pelvis.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ◆ Obtain a history of results of the patient's cardiovascular, hematopoietic, musculoskeletal, or reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ◆ Record the date of last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ◆ Obtain a list of the medications the patient is taking, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that no pain will be experienced during the test, but there may be moments of discomfort. Reassure the patient the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in an nuclear medicine department, by a HCP specializing in this procedure, with support staff, and takes approximately 1 to 3 hr.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ Instruct patients with diabetes to take their pretest dose of insulin at a meal 4 hr before the test
- ◆ Sometimes FDG examinations are done after blood has been drawn to

determine circulating blood glucose levels. If blood glucose levels are high, insulin may be given.

- ◆ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ◆ Instruct the patient to restrict food for 4 to 6 hr; restrict alcohol, nicotine, or caffeine-containing drinks for 24 hr; and withhold medications for 24 hr before the test. The exception is that there are no dietary restrictions for patients undergoing cardiac imaging. Protocols may vary from facility and facility.
- ◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ◆ Ensure that the patient has complied with dietary, fluid, and medication restrictions and pretesting preparations prior to the procedure.
- ◆ Ensure that the patient has removed external metallic objects from the area to be examined prior to the procedure.
- ◆ Have emergency equipment readily available.
- ◆ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ◆ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.
- ◆ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ◆ Cardiac imaging patients may be asked to ask to drink glucose prior to the radionuclide injection.
- ◆ Place the patient in the supine position on an exam table.
- ◆ The radionuclide is injected, and imaging is started after a 30-min delay. Images may be recorded for up to 3 hr postinjection.
- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

- Remove the needle or catheter and apply a pressure dressing over the puncture site.
- Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Instruct the patient to resume pretest diet, fluids, medications, and activity
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting. Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- Instruct the patient in the care and assessment of the injection site; have him or her observe for bleeding, hematoma formation, and inflammation.
- Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- Instruct the patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Educate the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- Instruct the patient to flush the toilet immediately after each voiding, and to meticulously wash hands with soap and water for 24 hr after the procedure.
- Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated, about 3 days. Instruct her to express the milk and discard it during the 3-day period to prevent cessation of milk production.

- Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and CAD.
- No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include AFP, Alzheimer's disease markers, amino acid screen, amylase, barium enema, biopsy breast, biopsy lung, bronchoscopy, calcitonin, CEA and cancer antigens, complete blood count, WBC count and differential, CSF analysis, colonoscopy, CT abdomen, CT brain, CT pancreas, CT pelvis, cytology sputum, evoked brain potentials, exercise stress test, fecal analysis, gallium scan, laparoscopy abdominal, laparoscopy gyn, lymphangiogram, mammography, MRI abdomen, MRI brain, MRI breast, MRI pelvis, myocardial perfusion heart scan, peritoneal fluid analysis, PET brain, PET heart, PET pelvis, proctosigmoidoscopy, stereotactic breast biopsy, US breast, US pancreas, US pelvis gyn, and WBC scan.
- Refer to the Cardiovascular, Hematopoietic, Musculoskeletal, or Reproductive System tables at the back of the book for related tests by body system.

Fecal Analysis

SYNONYM/ACRONYM: N/A.

SPECIMEN: Stool.

REFERENCE VALUE: (Method: Macroscopic examination, for appearance and color; microscopic examination, for cell count and presence of meat fibers; leukocyte esterase, for leukocytes; Clinitest [Bayer Corporation, Pittsburgh, Pennsylvania] for reducing substances; guaiac, for occult blood; x-ray paper, for trypsin).

Characteristic	Normal Result
Appearance	Solid and formed
Color	Brown
Epithelial cells	Few to moderate
Fecal fat	See "Fecal Fat" monograph
Leukocytes (white blood cells)	Negative
Meat fibers	Negative
Occult blood	Negative
Reducing substances	Negative
Trypsin	2+ to 4+

DESCRIPTION: Feces consist mainly of cellulose and other undigested foodstuffs, bacteria, and water. Other substances normally found in feces include epithelial cells shed from the gastrointestinal (GI) tract, small amounts of fats, bile pigments in the form of urobilinogen, GI and pancreatic secretions, electrolytes, and trypsin. Trypsin is a proteolytic enzyme produced in the pancreas. The average adult excretes 100 to 300 g of fecal material per day, the residue of approximately 10 L of liquid material that enters the GI tract each day. The laboratory analysis of feces includes macroscopic examination (volume, odor, shape, color, consistency, presence of mucus), microscopic examination

(leukocytes, epithelial cells, meat fibers), and chemical tests for specific substances (occult blood, trypsin, estimation of carbohydrate). Detection of occult blood is the most common test performed on stool. The prevalence of colorectal adenoma is greater than 30% in people aged 60 and older. Progression from adenoma to carcinoma occurs over a period of 5 to 12 yr; from carcinoma to metastatic disease in 2 to 3 yr. The American Cancer Society recommends one of several screening protocols beginning at age 50 to include: annual fecal occult blood, flexible sigmoidoscopy every 5 yr, double contrast barium enema every 5 yr, colonoscopy every 10 yr.

INDICATIONS:

- Assist in diagnosing disorders associated with GI bleeding or drug therapy that leads to bleeding
- Assist in the diagnosis of pseudomembranous enterocolitis after use of broad-spectrum antibiotic therapy
- Assist in the diagnosis of suspected inflammatory bowel disorder
- Detect altered protein digestion
- Detect intestinal parasitic infestation, as indicated by diarrhea of unknown cause
- Investigate diarrhea of unknown cause
- Monitor effectiveness of therapy for intestinal malabsorption or pancreatic insufficiency
- Screen for cystic fibrosis

RESULT:**Unusual Appearance:**

- Bloody: **Excessive intestinal wall irritation or malignancy**
- Bulky or frothy: **Malabsorption**
- Mucous: **Inflammation of intestinal walls**
- Slender or ribbonlike: **Obstruction**

Unusual Color:

- Black: **Bismuth (antacid) or charcoal ingestion, iron therapy, upper GI bleed**
- Grayish white: **Barium ingestion, bile duct obstruction**
- Green: **Antibiotics, biliverdin, green vegetables**
- Red: **Beets and food coloring, lower GI bleed, phenazopyridine hydrochloride compounds, rifampin**
- Yellow: **Rhubarb**

Increased:

- Carbohydrates/reducing substances: **Malabsorption syndromes**
- Epithelial cells: **Inflammatory bowel disorders**
- Leukocytes: **Bacterial infections of the intestinal wall, salmonellosis, shigellosis, and ulcerative colitis**

- Meat fibers: **Altered protein digestion**
- Occult blood: **Anal fissure, diverticular disease, esophageal varices, esophagitis, gastritis, hemorrhoids, infectious diarrheas, inflammatory bowel disease, Mallory-Weiss tears, polyps, tumors, ulcers**

Decreased:

- Leukocytes: **Amebic colitis, cholera, disorders resulting from toxins, parasites, viral diarrhea**
- Trypsin: **Cystic fibrosis, malabsorption syndromes, pancreatic deficiency**

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that can cause positive results for occult blood include acetylsalicylic acid, anticoagulants, colchicine, corticosteroids, iron preparations, and phenylbutazone.
- Ingestion of a diet high in red meat, certain vegetables, and bananas can cause false-positive results for occult blood.
- Large doses of vitamin C can cause false-negative occult blood.
- Constipated stools may not indicate any trypsin activity owing to extended exposure to intestinal bacteria.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of intestinal disorders.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's gastrointestinal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient of the procedure for collecting a stool sample, including the importance of good handwashing techniques. The patient should place the sample in a tightly covered container. Instruct the patient not to contaminate the specimen with urine, water, or toilet tissue. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient not to use laxatives, enemas, or suppositories for 3 days before the test.
- ▶ Instruct the patient to follow a normal diet. If the test is being performed to identify blood instruct the patient to follow a special diet that includes small amounts of chicken, turkey, and tuna (no red meats), raw and cooked vegetables and fruits, and bran cereal for several days before the test. Foods to avoid with the special diet include beets, turnips, cauliflower, broccoli, bananas, parsnips, and cantaloupe, since these foods can interfere with the occult blood test.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions; assure laxatives, enemas, or suppositories have been restricted for at least 3 days prior to the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date and time of collection, and suspected cause of enteritis; note any current or recent antibiotic therapy.

- ▶ Collect a stool specimen in a half-pint waterproof container with a tight-fitting lid; if the patient is not ambulatory, collect it in a clean, dry bedpan. Use a tongue blade to transfer the specimen to the container, and include any mucoid and bloody portions. Collect specimen from the first, middle, and last portion of the stool. The specimen should be refrigerated if it will not be transported to the laboratory within 4 hr after collection.
- ▶ To collect specimen by rectal swab, insert the swab past the anal sphincter, rotate gently, and withdraw. Place the swab in the appropriate container.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include α_1 -antitrypsin/phenotyping, barium enema, biopsy intestine, capsule endoscopy, CEA and cancer antigens, chloride sweat, colonoscopy, CT colonoscopy, culture stool, D-xylose tolerance, fecal fat, gliadin antibody, lactose tolerance test, ova and parasites, and proctosigmoidoscopy.
- ▶ Refer to the Gastrointestinal System table at the end of the book for related tests by body system.

Fecal Fat

SYNONYM/ACRONYM: Stool fat, fecal fat stain.

SPECIMEN: Stool (80 mL) aliquot from an unpreserved and homogenized 24- to 72-hr timed collection. Random specimens may also be submitted.

REFERENCE VALUE: (Method: Stain with Sudan black or oil red O. Treatment with ethanol identifies neutral fats; treatment with acetic acid identifies fatty acids.)

Neutral fat
Fatty acids

Age (diet)

Infant (breast milk)
0–6 yr
Adult

Adult (fat-free)

Random, Semiquantitative

Less than 50 fat globules/hpf*
Less than 100 fat globules/hpf

72-hr, Quantitative

Less than 1 g/24 hr
Less than 2 g/24 hr
2–7 g/24 hr; less than 20% of total solids
Less than 4 g/24 hr

*hpf = high-power field.

DESCRIPTION: Fecal fat primarily consists of triglycerides (neutral fats), fatty acids, and fatty acid salts. Through microscopic examination, the number and size of fat droplets can be determined as well as the type of fat present. Excretion of more than 7 g of fecal fat in a 24-hr period is abnormal but nonspecific for disease. Increases in excretion of neutral fats are associated with pancreatic exocrine insufficiency, whereas decreases are related to small bowel disease. An increase in triglycerides indicates that insufficient pancreatic enzymes are available to convert the triglycerides into fatty acids. Patients with malabsorption conditions have normal amounts of triglycerides but an

increase in total fecal fat because the fats are not absorbed through the intestine. Malabsorption disorders (e.g., cystic fibrosis) cause blockage of the pancreatic ducts by mucus, which prevents the enzymes from reaching the duodenum and results in lack of fat digestion. Without digestion, the fats cannot be absorbed, and steatorrhea results. The appearance and odor of stool from patients with steatorrhea is typically foamy, greasy, soft, and foul-smelling. The semiquantitative test is used to screen for the presence of fecal fat. The quantitative method, which requires a 72-hr stool collection, measures the amount of fat present in grams.

INDICATIONS:

- Assist in the diagnosis of malabsorption or pancreatic insufficiency, as indicated by elevated fat levels
- Monitor the effectiveness of therapy

RESULT:**Increased in:**

- Abetalipoprotein deficiency (*Related to lack of transport proteins for absorption*)
- Addison's disease (*Related to impaired transport*)
- Amyloidosis (*Increased rate of excretion related to malabsorption*)
- Bile salt deficiency (*Lack of bile salts affects proper fat digestion*)
- Carcinoid syndrome (*Increased rate of excretion related to malabsorption*)
- Celiac disease (*Increased rate of excretion related to malabsorption*)
- Crohn's disease (*Increased rate of excretion related to malabsorption*)
- Cystic fibrosis (*Related to insufficient digestive enzymes*)
- Diabetes (*Abnormal motility related to primary condition*)
- Enteritis (*Increased rate of excretion related to malabsorption*)
- Malnutrition (*Related to detrimental effects on organs and systems responsible for digestion, transport, and absorption*)
- Multiple sclerosis (*Abnormal motility related to primary condition*)
- Pancreatic insufficiency or obstruction (*Related to insufficient digestive enzymes*)
- Peptic ulcer disease (*Related to improper digestion due to low pH*)
- Pernicious anemia (*Related to bacterial overgrowth that decreases*

overall absorption and results in vitamin B₁₂ deficiency)

- Progressive systemic sclerosis (*Abnormal motility related to primary condition*)
- Thyrotoxicosis (*Abnormal motility related to primary condition*)
- Tropical sprue (*Increased rate of excretion related to malabsorption*)
- Viral hepatitis (*Related to insufficient production of digestive enzymes and bile*)
- Whipple's disease (*Increased rate of excretion related to malabsorption*)
- Zollinger-Ellison syndrome (*Related to improper digestion due to low pH*)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Cimetidine has been associated with decreased fecal fat in some patients with cystic fibrosis who are also receiving pancreatic enzyme therapy.
- Some drugs cause steatorrhea as a result of mucosal damage. These include colchicine, kanamycin, lincomycin, methotrexate, and neomycin. Other drugs that can cause an increase in fecal fat include aminosalicic acid, bisacodyl and phenolphthalein (observed in laxative abusers), and cholestyramine (in high doses).
- Use of suppositories, oily lubricants, or mineral oil in the perianal area for 3 days before the test can falsely increase neutral fats.
- Use of herbals with laxative effects, including cascara, psyllium, and senna, for 3 days before the test can falsely increase neutral fats.

- Barium interferes with test results.
- Failure to collect all stools may reflect falsely decreased results.
- Ingestion of a diet too high or low in fats may alter the results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of malabsorption syndromes.
- ▶ Obtain a history of the patient's complaints that indicate a gastrointestinal (GI) disorder, diarrhea related to GI dysfunction, pain related to tissue inflammation or irritation, alteration in diet resulting from an inability to digest certain foods, or fluid volume deficit related to active loss. Obtain a history of known allergens.
- ▶ Obtain a history of the patient's GI and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Stress the importance of collecting all stools for the quantitative test, including diarrhea, over the timed specimen-collection period. Inform the patient not to urinate in the stool-collection container and not to put toilet paper in the container. Address concerns about pain related to the procedure. Explain to the patient that there should be no discomfort during the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during and after the procedure.
- ▶ Instruct the patient not to use laxatives, enemas, or suppositories for 3 days before the test.
- ▶ There are no fluid restrictions, unless by medical direction.

- ▶ Instruct the patient to ingest a diet containing 50 to 150 g of fat for at least 3 days before beginning specimen collection. This approach does not work well with children; instruct the caregiver to record the child's dietary intake to provide a basis from which an estimate of fat intake can be made.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and other pretesting preparations prior to the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and the start and stop times of collection.
- ▶ Obtain the appropriate-sized specimen container, toilet-mounted collection container to aid in specimen collection, and plastic bag for specimen transport. A large, clean, preweighed container should be used for the timed test. A smaller, clean container can be used for the collection of the random sample.
- ▶ For the quantitative procedure, instruct the patient to collect each stool and place it in the 500-mL container during the timed collection period. Keep the container refrigerated in the plastic bag throughout the entire collection period.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and medication, as directed by the HCP.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Instruct the patient with abnormal values on the importance of fluid intake and proper diet specific to his or her condition. Provide teaching and information regarding the clinical

implications of the test results, as appropriate. Educate the patient regarding access to counseling services.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation

to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include α_1 -antitrypsin/phenotyping, biopsy intestine, chloride sweat, complete blood count, complete blood count, RBC indices, complete blood count, RBC morphology, D-xylose tolerance test, fecal analysis, folate, gastric acid stimulation test, gastric emptying scan, radioactive iodine uptake, and vitamin B₁₂.
- ▶ Refer to the Gastrointestinal and Respiratory System tables at the back of the book for related tests by body system.

F

Ferritin

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Age	Conventional Units	SI Units (Conventional Units × 1)
Newborn	25–200 ng/mL	25–200 mcg/L
1 mo	200–600 ng/mL	200–600 mcg/L
2–5 mo	50–200 ng/mL	50–200 mcg/L
6 mo–15 yr	7–140 ng/mL	7–140 mcg/L
Adult		
Men	20–250 ng/mL	20–250 mcg/L
Women younger than 40 yr	10–120 ng/mL	10–120 mcg/L
Women 40 yr and older	12–263 ng/mL	12–263 mcg/L

DESCRIPTION: Ferritin, a protein manufactured in the liver, spleen, and bone marrow, consists of a protein shell, apoferritin, and an iron core. The amount of ferritin in the circulation is usually proportional to the amount of stored iron (ferritin and hemosiderin)

in body tissues. Levels vary according to age and gender, but they are not affected by exogenous iron intake or subject to diurnal variations. Compared to iron and total iron-binding capacity, ferritin is a more sensitive and specific test for diagnosing

iron-deficiency anemia. Iron-deficiency anemia in adults is indicated at ferritin levels less than 10 ng/mL; hemochromatosis or hemosiderosis is indicated at levels greater than 400 ng/mL.

INDICATIONS:

- Assist in the diagnosis of iron-deficiency anemia
- Assist in the differential diagnosis of microcytic, hypochromic anemias
- Monitor hematological responses during pregnancy, when serum iron is usually decreased and ferritin may be decreased
- Support diagnosis of hemochromatosis or other disorders of iron metabolism and storage

RESULT:

Increased in:

- Alcoholism (*Active abuse, ferritin is released into the circulation from damaged hepatocytes and RBCs*)
- Breast cancer (*Acute, ferritin is an acute phase reactant protein; chronic, pathophysiology is uncertain*)
- Hemochromatosis (*Increased iron deposits in the liver stimulate ferritin production*)
- Hemolytic anemia (*Increased iron levels from hemolyzed RBCs stimulate ferritin production*)
- Hemosiderosis (*Increased iron levels stimulate ferritin production*)
- Hepatocellular disease (*Acute, ferritin is an acute phase reactant protein; chronic, ferritin is released into the circulation from damaged hepatocytes*)
- Hodgkin's disease (*Acute, ferritin is an acute phase reactant protein; chronic, pathophysiology is uncertain*)

- Hyperthyroidism (*Possibly related to the stimulating effect of TSH on ferritin production*)
- Infection (*Acute, ferritin is an acute phase reactant protein; chronic, pathophysiology is uncertain*)
- Inflammatory diseases (*Ferritin is an acute phase reactant protein*)
- Leukemias (*Acute, ferritin is an acute phase reactant protein; chronic, pathophysiology is uncertain*)
- Oral or parenteral administration of iron (*An increased circulating iron level stimulates ferritin production*)
- Thalassemia (*Increased iron levels from hemolyzed RBCs stimulate ferritin production*)

Decreased in:

Conditions that decrease iron stores result in corresponding low levels of ferritin.

- Hemodialysis
- Iron-deficiency anemia

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase ferritin levels include ethanol, ferric polymaltose, iron, and oral contraceptives.
- Drugs that may decrease ferritin levels include erythropoietin, methimazole, propylthiouracil, and thiamazole.
- Recent transfusion can elevate serum ferritin.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of hypochromic, microcytic anemias.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations:* Nutritional therapy may be indicated for patients with decreased ferritin values because this may indicate corresponding iron deficiency. Instruct these patients in the dietary inclusion of iron-rich foods and in the administration of iron supplements, including side effects, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, biopsy liver, complement, complete blood count, complete blood count, hematocrit, complete blood count, hemoglobin, complete blood count, platelet count, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology and inclusions, complete blood count, WBC count and differential, Coomb's antiglobulin direct and indirect, erythropoietin, FEP, G6PD, Ham's test, Hgb electrophoresis, hemosiderin, iron/TIBC, osmotic fragility, PK, sickle cell screen, and transferrin.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Fetal Fibronectin

SYNONYM/ACRONYM: fFN.

SPECIMEN: Swab of vaginal secretions

REFERENCE VALUE: (Method: Immunoassay) Less than 0.05 mcg/mL.

DESCRIPTION: Fibronectin is a protein found in fetal connective tissue, amniotic fluid, and the placenta of pregnant women. Placental fFN is concentrated in the area where the placenta and its membranes are in contact with the uterine wall. It is first secreted early in pregnancy and is believed to help implantation of the fertilized egg to the uterus. Fibronectin is not detectable again until 22 to 34 wk of gestation; if it is detected in vaginal secretions at this gestational age, delivery may happen prematurely. The test is a useful marker for impending membrane rupture within 7 to 14 days if the level rises to greater than 0.05 mcg/mL.

INDICATIONS:

Investigate signs of premature labor

RESULT:

Positive findings in:

- Premature labor (**Possibly initiated by mechanical or infectious processes, the membranes pull away from the uterine wall and amniotic fluid containing fFN leaks into endocervical fluid**)

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

If signs and symptoms persist in light of negative test results, repeat testing may be necessary.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess the risk of preterm delivery.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that the patient knows the symptoms of premature labor, which include uterine contractions (with or without pain) lasting 20 sec or longer or increasing in frequency, menstrual-like cramping (intermittent or continuous), pelvic pressure, lower back pain that does not dissipate with a change in position, persistent diarrhea, intestinal cramps, changes in vaginal discharge, or a feeling that something is wrong.
- ▶ The health care provider (HCP) should be informed if contractions occur more frequently than 4 times per hr.
- ▶ Obtain a list of the patient's current medications, including herbs,

F

nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min and will be performed by a HCP specializing in this branch of medicine. Address concerns about pain related to the procedure. Explain to the patient that there should be minimal to no discomfort during the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
- ▶ Position the patient on the gynecological examination table with the feet up in stirrups. Drape the patient's legs to provide privacy and to reduce chilling. Collect a small amount of vaginal secretion using a special swab from a fetal fibronectin kit.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain the possible causes and increased risks associated with premature labor and delivery. Reinforce education on signs and symptoms of labor, as appropriate. Inform the patient that hospitalization or more frequent prenatal checks may be ordered. Other therapies may also be administered, such as antibiotics, corticosteroids, and IV tocolytics. Instruct the patient in the importance of completing the entire course of antibiotic therapy, if ordered, even if no symptoms are present. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amniotic fluid analysis (nitrazine and fern test), biopsy chorionic villus, chromosome analysis, estradiol, α_1 -fetoprotein, HCG, LS ratio, progesterone, and US biophysical profile obstetric.
- ▶ Refer to the Reproductive System table at the end of the book for related tests by body system.

α_1 -Fetoprotein

SYNONYM/ACRONYM: AFP.

SPECIMEN: Serum (1 mL for tumor marker in men and nonpregnant women; 3 mL for maternal triple- or quad-marker testing), collected in a red- or tiger-top tube. For maternal triple- or quad-marker testing, include human chorionic gonadotropin and free estriol measurement.

REFERENCE VALUE: (Method: Immunoassay for tumor marker, radioimmunoassay for maternal triple- or quad-marker testing)

Tumor Marker: Men, Women, and Children.

AFP

Men, Non-Pregnant Women, and Children 0–15 ng/mL

AFP in Maternal Serum for Triple or Quad Marker

	White AFP (Median)	Black AFP (Median)	Hispanic AFP (Median)	Asian AFP (Median)
Low risk	Less than 2 MoM	Less than 2 MoM	Less than 2 MoM	Less than 2 MoM
Gestational Age (wk)				
14	19.9 ng/mL	23.2 ng/mL	18.3 ng/mL	22.4 ng/mL
15	23.2 ng/mL	26.9 ng/mL	22.6 ng/mL	28.3 ng/mL
16	27.0 ng/mL	31.1 ng/mL	27.3 ng/mL	32.7 ng/mL
17	31.5 ng/mL	35.9 ng/mL	32.3 ng/mL	37.9 ng/mL
18	36.7 ng/mL	41.6 ng/mL	38.1 ng/mL	44.8 ng/mL
19	42.7 ng/mL	48.0 ng/mL	45.0 ng/mL	52.0 ng/mL
20	49.8 ng/mL	55.6 ng/mL	52.2 ng/mL	62.2 ng/mL
21	58.1 ng/mL	64.2 ng/mL	61.9 ng/mL	79.5 ng/mL
22	67.8 ng/mL	74.2 ng/mL	64.3 ng/mL	78.2 ng/mL

MoM = multiples of the median.

HCG and Estriol in Maternal Serum

Gestational Age (wk)

	HCG Median Value	Free Estriol Median Value
14	41.5 international units/mL	0.5 ng/mL
15	36.0 international units/mL	0.7 ng/mL
16	31.0 international units/mL	0.9 ng/mL
17	27.0 international units/mL	1.1 ng/mL
18	24.0 international units/mL	1.4 ng/mL
19	21.0 international units/mL	1.8 ng/mL
20	18.0 international units/mL	2.3 ng/mL
21	16.0 international units/mL	2.8 ng/mL
22	14.0 international units/mL	3.6 ng/mL

Results vary widely from laboratory to laboratory and method to method.
HCG = human chorionic gonadotropin.

DESCRIPTION: α_1 -Fetoprotein (AFP) is a glycoprotein produced in the fetal liver, gastrointestinal tract, and yolk sac. AFP is the major serum protein produced for 10 wk in early fetal life. (See “Amniotic Fluid Analysis” monograph for measurement of AFP levels in amniotic fluid.) After 10 wk of gestation, levels of fetal AFP can be detected in maternal blood, with peak levels occurring at 16 to 18 wk. Elevated maternal levels of AFP on two tests taken 1 wk apart suggest further investigation into fetal well-being by ultrasound or amniocentesis. Human chorionic gonadotropin (HCG), a hormone secreted by the placenta, stimulates secretion of progesterone by the corpus luteum. (The use of HCG as a triple marker is also discussed in the monograph titled “Human Chorionic Gonadotropin.”) During intrauterine development, the normal fetus and placenta produce estriol, a portion of which passes into maternal circulation. Decreased estriol levels are an independent indicator of neural tube defects. The incidence of neural tube defects is about 1 in 1000 births. Dimeric inhibin-A (DIA) is the fourth biochemical marker used in prenatal screening. It is a glycoprotein secreted by the placenta. Maternal blood levels of DIA normally remain fairly stable during the 15th to 18th wk of pregnancy. Blood levels are twice as high in the second trimester of pregnancies affected by Down syndrome. The triple screen detection rate for Down syndrome is 67%. The Down syndrome detection rate increases to 76% and maintains a false-positive rate of 5% when DIA is included.

The presence of AFP in excessive amounts is abnormal in adults and children. AFP measurements are used as a tumor marker to assist in the diagnosis of cancer.

INDICATIONS:

- Assist in the diagnosis of primary hepatocellular carcinoma or metastatic lesions involving the liver, as indicated by highly elevated levels (30% to 50% of Americans with liver cancer do not have elevated AFP levels)
- Investigate suspected hepatitis or cirrhosis, indicated by slightly to moderately elevated levels
- Monitor response to treatment for hepatic carcinoma, with successful treatment indicated by an immediate decrease in levels
- Monitor for recurrence of hepatic carcinoma, with elevated levels occurring 1 to 6 mo before the patient becomes symptomatic
- Investigate suspected intrauterine fetal death, as indicated by elevated levels
- Routine prenatal screening at 13 to 16 wk of pregnancy for fetal neural tube defects and other disorders, as indicated by elevated levels in maternal serum and amniotic fluid
- Support diagnosis of embryonal gonadal teratoblastoma, hepatoblastoma, and testicular or ovarian carcinomas

RESULT:

Maternal serum AFP test results report actual values and multiples of the median (MoM) by gestational age (in weeks). MoM are calculated by dividing the patient's AFP by the midpoint (or median) of values expected for a large population of unaffected women at the same gestational age in weeks. MoM should be corrected for

maternal weight. The MoM should also be corrected for maternal insulin requirement (achieved by dividing MoM by 1.1 for diabetic African American patients and by 0.8 for diabetic patients of other races) and multiple fetuses (multiply by 2.13 for twins). Some laboratories also provide additional statistical information regarding Down syndrome risk.

Increased in:

- Pregnant women:
 - Congenital nephrosis (*Related to defective renal reabsorption*)
 - Fetal abdominal wall defects (*Related to release of AFP from open body wall defect*)
 - Fetal distress
 - Fetal neural tube defects (e.g., anencephaly, spina bifida, myelomeningocele) (*Related to release of AFP from open body wall defect*)
 - Low birth weight (*Related to inaccurate estimation of gestational age*)
 - Multiple pregnancy (*Related to larger quantities from multiple fetuses*)
 - Polycystic kidneys (*Related to defective renal reabsorption*)
 - Underestimation of gestational age (*Related to the expectation of a lower value based on incorrect prediction of gestational age, i.e., AFP increases with age; therefore, if the age is believed to less than it is actually, the expectation of the corresponding AFP value will be lower than it is actually, and the result appears to be elevated*)
- Men, nonpregnant women, and children: (*The cancer cells contain undifferentiated hepatocytes that produce glycoproteins of fetal origin*)
 - Cirrhosis
 - Hepatic carcinoma
 - Hepatitis
 - Metastatic lesions involving the liver

Decreased in:

- Pregnant women:
 - Down syndrome (trisomy 21)
 - Edwards' syndrome (trisomy 18)

Fetal demise (undetected over a lengthy period of time) (*Related to cessation of AFP production*)

Hydatidiform moles (*Partial mole may secrete some AFP*)

Overestimation of gestational age (*Related to the expectation of a higher value based on incorrect prediction of gestational age, i.e., AFP increases with age; therefore, if the age is believed to greater than it is actually, the expectation of the corresponding AFP value will be greater than it actually, and the result appears to be decreased*)

Pseudopregnancy (*There is no fetus to produce AFP*)

Spontaneous abortion (*There is no fetus to produce AFP*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may decrease AFP levels in pregnant women include acetaminophen, acetylsalicylic acid, and phenacetin.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.
- Multiple fetuses can cause increased levels.
- Gestational age must be between 15 and 22 wk for initial and follow-up testing. The most common cause of an abnormal MoM is inaccurate estimation of gestational age (defined as weeks from the first day of the last menstrual period).
- Maternal AFP levels vary by race.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is primarily used to screen for neural tube defects.
- ▶ Obtain a history of the patient's complaints and known or suspected malignancy. Obtain a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and reproductive systems, gestational age, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Provide required information to laboratory for triple-marker testing, including maternal birth date, weight, age, race, calculated gestational age, gestational age by ultrasound, gestational date by physical examination, first day of last menstrual period, estimated date of delivery, and whether the patient has insulin-dependent (type 1) diabetes.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- ▶ The sample may be collected directly from the cord using a syringe and transferred to a red-top tube.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations:* Hyperhomocysteinemia resulting from folate deficiency in pregnant women is believed to increase the risk of neural tube defects. Elevated levels of homocysteine are thought to chemically damage the exposed neural tissue of the developing fetus. As appropriate, instruct pregnant women to eat foods rich in folate, such as liver, salmon, eggs, asparagus, green leafy vegetables, broccoli, sweet potatoes, beans, and whole wheat.
- ▶ *Social and cultural considerations:* In pregnant patients, recognize anxiety related to test results, and encourage the family to seek counseling if concerned with pregnancy termination or to seek genetic counseling if a chromosomal abnormality is determined. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Decisions regarding elective abortion should take place in the presence of both parents. Provide a nonjudgmental, nonthreatening atmosphere for discussing the risks and difficulties of delivering and raising a developmentally challenged infant, as well as exploring other options (termination of pregnancy or adoption). It is also important to discuss feelings the mother and father may experience (e.g., guilt, depression, anger) if fetal abnormalities are detected. Educate the patient regarding access to counseling services.

- ▶ In patients with carcinoma, recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in

therapy. Inform the pregnant patient that an ultrasound may be performed and AFP levels in amniotic fluid may be analyzed if maternal blood levels are elevated in two samples obtained 1 wk apart. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amniotic fluid analysis, biopsy chorionic villus, CEA and cancer antigens, estradiol, fetal fibronectin, folic acid, hexosaminidase, homocysteine, HCG, L/S ratio, and US biophysical profile obstetric.
- ▶ Refer to the Immune and Reproductive System tables at the end of the book for related tests by body system.

F

Fibrin Degradation Products

SYNONYM/ACRONYM: Fibrin split products, fibrin breakdown products, FDP, FSP, FBP.

SPECIMEN: Plasma (1 mL) collected in special blue-top tube containing thrombin and a protease inhibitor.

REFERENCE VALUE: (Method: Latex agglutination)

Conventional Units	SI Units (Conventional Units × 1)
Less than 5 mcg/mL	Less than 5 mg/dL

DESCRIPTION: This coagulation test evaluates fibrin split products or fibrin/fibrinogen degradation products that interfere with normal coagulation and formation of the hemostatic platelet plug. After a fibrin clot has formed, the fibrinolytic system prevents excessive clotting. In the fibrinolytic system, plasmin digests fibrin. Fibrinogen also can be degraded

if there is a disproportion among plasmin, fibrin, and fibrinogen. Seven substances labeled *A, B, C, D, E, X,* and *Y* result from this degradation, which can indicate abnormal coagulation. Under normal conditions, the liver and reticuloendothelial system remove fibrin split products from the circulation.

INDICATIONS:

- Assist in the diagnosis of suspected disseminated intravascular coagulation (DIC)
- Evaluate response to therapy with fibrinolytic drugs
- Monitor the effects on hemostasis of trauma, extensive surgery, obstetric complications, and disorders such as liver or renal disease

RESULT:**Increased in:**

- DIC (*FDP can be positive in a number of conditions where the coagulation system has been excessively stimulated as a result of tissue injury and fibrin and/or fibrinogen is being degraded by plasmin*)
- Excessive bleeding (*Clot formation related to depletion of platelets and clotting factors will stimulate fibrinolysis and increase circulation of fibrin breakdown products*)
- Liver disease (*Related to decreased hepatic clearance*)
- Myocardial infarction (*FDP can be positive in a number of conditions where the coagulation system has been excessively stimulated as a result of tissue injury and fibrin and/or fibrinogen is being degraded by plasmin*)
- Obstetric complications, such as pre-eclampsia, abruptio placentae, intrauterine fetal death (*Excessive stimulation of the coagulation system, microthrombi are formed and plasminogen is released to dissolve the fibrin clots*)
- Post-cardiothoracic surgery period (*FDP can be positive in a number of conditions where the coagulation system has been excessively stimulated as a result of tissue injury and fibrin and/or fibrinogen is being degraded by plasmin*)

- Pulmonary embolism (*FDP can be positive in a number of conditions where the coagulation system has been excessively stimulated as a result of tissue injury and fibrin and/or fibrinogen is being degraded by plasmin*)
- Renal disease (*FDP can be positive in a number of conditions where the coagulation system has been excessively stimulated as a result of tissue injury and fibrin and/or fibrinogen is being degraded by plasmin*)
- Renal transplant rejection

CRITICAL VALUES:**Greater than 40 mcg/mL**

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms.

INTERFERING FACTORS:

- Traumatic venipunctures and excessive agitation of the sample can alter test results.
- Drugs that may increase fibrin degradation product levels include heparin and fibrinolytic drugs such as streptokinase and urokinase.
- The presence of rheumatoid factor may falsely elevate results with some test kits.
- The test should not be ordered on patients receiving heparin therapy.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate conditions associated with abnormal fibrinolytic and fibrinogenolytic activity, such as DIC, deep vein thrombosis, and pulmonary embolism.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular and hematopoietic systems, any bleeding disorders, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and utraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for

- bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to report bleeding from skin or mucous membranes, ecchymosis, petechiae, hematuria and occult blood.
- ▶ Inform the patient with increased levels of fibrin degradation products of the importance of taking precautions against bruising and bleeding, including the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of acetylsalicylic acid and similar products, and avoidance of intramuscular injections.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include aPTT, ALT, alveolar/arterial gradient, angiography pulmonary, AT-III, AST, bilirubin, biopsy liver, blood pool imaging, BUN, coagulation factors, CT cardiac scoring, creatinine, complete blood count, CK and isoenzymes, CRP, D-dimer, exercise stress test, FDP, fibrinogen, GGT, lung perfusion scan, lung ventilation scan, myoglobin, plasminogen, platelet count, PET heart, protein S, PT/INR, troponin, US venous doppler extremity studies, and venography lower extremity studies.
- ▶ Refer to the Cardiovascular and Hematopoietic System tables at the end of the book for related tests by body system.

Fibrinogen

SYNONYM/ACRONYM: Factor I.

SPECIMEN: Plasma (1 mL) collected in blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Photo-optical clot detection)

Age	Conventional Units	SI Units (Conventional Units × 0.01)
Newborn	125–300 mg/dL	1.25–3.00 g/L
Adult	200–400 mg/dL	2.00–4.00 g/L

DESCRIPTION: Fibrinogen (factor I) is synthesized in the liver. In the common final pathway of the coagulation sequence, thrombin converts fibrinogen to fibrin, which then clots blood as it combines with platelets. In normal, healthy individuals, the serum should contain no residual fibrinogen after clotting has occurred.

INDICATIONS:

- Assist in the diagnosis of suspected disseminated intravascular coagulation (DIC), as indicated by decreased fibrinogen levels
- Evaluate congenital or acquired dysfibrinogenemias
- Monitor hemostasis in disorders associated with low fibrinogen levels or elevated levels that can predispose patients to excessive thrombosis

RESULT:

Increased in:

Fibrinogen is an acute phase reactant protein and will be increased in inflammatory conditions.

- Acute myocardial infarction
- Cancer

- Eclampsia
- Hodgkin's disease
- Inflammation
- Multiple myeloma
- Nephrotic syndrome
- Pregnancy
- Tissue necrosis

Decreased in:

- Congenital fibrinogen deficiency (rare) (**Related to deficient synthesis**)
- DIC (**Fibrinogen is converted to fibrin**)
- Dysfibrinogenemia (**Inherited abnormality in fibrinogen synthesis**)
- Liver disease (severe) (**Related to decreased synthesis**)
- Primary fibrinolysis (**During fibrinolysis plasmin breaks down fibrinogen and fibrin**)

CRITICAL VALUES:



Less than 80 mg/dL

Note and immediately report to the health care provider (HCP) any critically decreased values and related symptoms. Signs and symptoms of microvascular thrombosis include cyanosis, ischemic tissue necrosis, hemorrhagic necrosis, tachypnea, dyspnea, pulmonary emboli, venous distention, abdominal pain, and

oliguria. Possible interventions include identification and treatment of the underlying cause, support through administration of required blood products (platelets, cryoprecipitate, or fresh frozen plasma), and administration of heparin.

INTERFERING FACTORS:

- Drugs that may increase fibrinogen levels include acetylsalicylic acid, norethandrolone, oral contraceptives, oxandrolone, and oxymetholone.
- Drugs that may decrease fibrinogen levels include anabolic steroids, asparaginase, bezafibrate, danazol, dextran, fenofibrate, fish oils, gemfibrozil, lovastatin, pentoxifylline, phosphorus, and ticlopidine.
- Transfusions of whole blood, plasma, or fractions within 4 wk of the test invalidate results.
- Placement of tourniquet for longer than 1 min can result in venous stasis and changes in the concentration of plasma proteins to be measured. Platelet activation may also occur under these conditions, causing erroneous results.
- Vascular injury during phlebotomy can activate platelets and coagulation factors, causing erroneous results.
- Hemolyzed specimens must be rejected because hemolysis is an indication of platelet and coagulation factor activation.
- Incompletely filled tubes contaminated with heparin or clotted specimens must be rejected.
- Icteric or lipemic specimens interfere with optical testing methods, producing erroneous results.
- Traumatic venipuncture and excessive agitation of the sample can alter test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate fibrinolytic activity as well as identify congenital deficiency and disseminated intravascular coagulation (DIC).
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern or modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate

tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a 5-mL blue-top tube. Fill the tube completely.

Important note: Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range.

- ◆ When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and nonadditive red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with tissue thromboplastin, which can falsely decrease values.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed specimens stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to report bruising, petechiae, and bleeding from mucous membranes, hematuria and occult blood.
- ◆ Inform the patient with a decreased fibrinogen level of the importance of taking precautions against bruising and bleeding, including the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of acetylsalicylic acid and similar products, and avoidance of intramuscular injections.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ALT, albumin, ALP, AT-III, AST, bilirubin, biopsy bone, biopsy bone marrow, biopsy liver, clot retraction, coagulation factors, complete blood count, platelet count, CT cardiac scoring, CK and isoenzymes, CRP, D-dimer, echocardiography, echocardiography transesophageal, ECG, ESR, exercise stress test, FDP, GGT, Holter monitor, IFE, immunoglobulins, myocardial perfusion heart scan, aPTT, plasminogen, protein S, and PT/INR.
- ◆ Refer to the Hematopoietic and Hepatobiliary System tables at the back of the book for related tests by body system.

Fluorescein Angiography

SYNONYM/ACRONYM: FA.

AREA OF APPLICATION: Eyes.

CONTRAST: Fluorescein dye.

DESCRIPTION: Fluorescein angiography (FA) involves the color radiographic examination of the retinal vasculature following rapid IV injection of a sodium fluorescein contrast medium. A special camera allows images to be taken in sequence and manipulated by a computer to provide views of the retinal vessels during filling and emptying of the dye. The camera allows only light waves in the blue range to strike the fundus of the eye. When the fluorescein reaches the blood vessels in the eye, blue light excites the dye molecules to a higher state of activity and causes them to emit a greenish-yellow fluorescence that is recorded.

INDICATIONS:

- Detect arterial or venous occlusion evidenced by the reduced, delayed, or absent flow of the contrast medium through the vessels or possible vessel leakage of the medium
- Detect possible vascular disorders affecting visual acuity
- Detect presence of microaneurysms caused by hypertensive retinopathy
- Detect the presence of tumors, retinal edema, or inflammation, as evidenced by abnormal patterns or degree of fluorescence
- Diagnose diabetic retinopathy
- Diagnose past reduced flow or

patency of the vascular circulation of the retina, as evidenced by neovascularization

- Diagnose presence of macular degeneration and any other degeneration and any associated hemorrhaging
- Observe ocular effects resulting from the long-term use of high-risk medications

RESULT:

Normal findings in:

- No leakage of dye from retinal blood vessels
- Normal retina and retinal and choroidal vessels
- No evidence of vascular abnormalities, such as hemorrhage, retinopathy, aneurysms, or obstructions caused by stenosis and resulting in collateral circulation

Abnormal findings in:

- Aneurysm
- Arteriovenous shunts
- Diabetic retinopathy
- Macular degeneration
- Neovascularization
- Obstructive disorders of the arteries or veins that lead to collateral circulation

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with a past history of hypersensitivity to radiographic dyes

- Patients with narrow-angle glaucoma if pupil dilation is performed; dilation can initiate a severe and sight-threatening open-angle attack
- Patients with allergies to mydriatics if pupil dilation using mydriatics is performed

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the test because of age, significant pain, or mental status may interfere with the test results.
- Presence of cataracts may interfere with fundal view.
- Ineffective dilation of the pupils may impair clear imaging.
- Allergic reaction to radiographic dye, including nausea and vomiting.
- Failure to follow medication restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test detects possible vascular disorders of the eye.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to radiographic dyes, shellfish, and bee venom.
- ▶ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; and eye conditions with treatment regimens.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.
- ▶ Review the procedure with the patient. Explain that the patient will be requested to fixate the eyes during the procedure. Address concerns about pain and explain that mydriatics, if used, may cause blurred vision and sensitivity to light. There may also be a brief stinging sensation when the drop is put in the eye. Explain to the patient that some discomfort may be experienced during the insertion of the IV. Inform the patient that, when fluorescein dye is injected, it may cause facial flushing or nausea and vomiting. Inform the patient that a health care provider (HCP) performs the test, in a quiet, darkened room, and that to dilate and evaluate both eyes, the test can take up to 60 min.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line will be inserted to allow intermittent infusion of dye.
- ▶ There are no food or fluid restrictions, unless by medical direction.
- ▶ The patient should avoid eye medications (particularly mydriatic eye drops if the patient has glaucoma) for at least 1 day prior to the test.
- ▶ Ensure that the patient understands that he or she must refrain from driving until the pupils return to normal (about 4 hr) after the test and has made arrangements to have someone else be responsible for transportation after the test.
- ▶ **Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.**

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions; assure that eye medications, especially mydriatics, have been withheld for at least 1 day prior to the test.
- ▶ Have emergency equipment readily available.

- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still during the procedure because movement produces unreliable results.
 - ▶ Seat the patient in a chair that faces the camera. Instruct the patient to look at directed target while the eyes are examined.
 - ▶ If dilation is to be performed, administer the ordered mydriatic to each eye and repeat in 5 to 15 min. Drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semi-transparent area of the eyeball where the cornea and sclera meet). Neither dropper nor bottle should touch the eyelashes.
 - ▶ Insert an intermittent infusion device, as ordered, for subsequent injection of the contrast media or emergency medications.
 - ▶ After the eyedrops are administered but before the dye is injected, color fundus photographs are taken.
 - ▶ Instruct the patient to place the chin in the chin rest and gently press the forehead against the support bar. Instruct the patient to open his or her eyes wide and look at the desired target.
 - ▶ Fluorescein dye is injected into the brachial vein using the intermittent infusion device, and a rapid sequence of photographs are taken and repeated after the dye has reached the retinal vascular system. Follow-up photographs are taken in 20 to 30 min.
 - ▶ At the conclusion of the procedure, remove the IV needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
 - ▶ Observe for hypersensitive reaction to the dye. The patient may become nauseous and vomit.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to vision loss or anticipated loss of driving privileges. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide contact information regarding vision aids, if desired, for ABLEDATA (sponsored by the National Institute on Disability and Rehabilitation Research [NIDRR], available at www.abledata.com). Information can also be obtained from the American Macular Degeneration Foundation (www.macular.org), the Glaucoma Research Foundation (www.glaucoma.org), and the American Diabetes Association (www.diabetes.org).
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that visual acuity and responses to light may change. Suggest that the patient wear dark glasses after the test until the pupils return to normal size. Inform the patient that yellow discoloration of the skin and urine from the radiographic dye is normally present for up to 2 days. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications, as directed by the HCP.
- ▶ Related tests include fructosamine, fundus photography, glucagon, glucose, glycated hemoglobin, gonioscopy, insulin, intraocular pressure, microalbumin, plethysmography, refraction, slit-lamp biomicroscopy, and visual field testing.
- ▶ Refer to the Ocular System table at the back of the book for related tests by body system.

Folate

SYNONYM/ACRONYM: Folic acid, Vitamin B₉.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

Age	Conventional Units	SI Units (Conventional Units × 2.265)
Newborn–1 yr	5–21 ng/mL	11–48 nmol/L
Adult	Greater than 2.5 ng/mL	Greater than 5.7 nmol/L

DESCRIPTION: Folate, a water-soluble vitamin, is produced by bacteria in the intestines and stored in small amounts in the liver. Dietary folate is absorbed through the intestinal mucosa and stored in the liver. Folate is necessary for normal red blood cell and white blood cell function, DNA replication, and cell division. Folate levels are often measured in association with serum vitamin B₁₂ determinations since vitamin B₁₂ is required for folate to enter tissue cells. Folate is an essential coenzyme in the conversion of homocysteine to methionine. Hyperhomocysteinemia resulting from folate deficiency in pregnant women is believed to increase the risk of neural tube defects. Hyperhomocysteinemia related to low folic acid levels is also associated with increased risk for cardiovascular disease.

INDICATIONS:

- Assist in the diagnosis of megaloblastic anemia resulting from deficient folate intake or increased folate requirements, such as in pregnancy and hemolytic anemia

- Monitor the effects of prolonged parenteral nutrition
- Monitor response to disorders that may lead to folate deficiency or decreased absorption and storage

RESULT:

Increased in:

- Blind loop syndrome (*Malabsorption in a segment of the intestine due to competition for absorption of folate produced by bacterial overgrowth*)
- Excessive dietary intake of folate or folate supplements
- Pernicious anemia (*Inadequate levels of vitamin B₁₂, due to impaired absorption, result in increased circulating folate levels*)
- Vitamin B₁₂ deficiency (*Inadequate levels of vitamin B₁₂ to metabolize folate result in increased circulating folate levels*)

Decreased in:

- Chronic alcoholism (*Insufficient intake combined with malabsorption*)
- Crohn's disease (*Related to malabsorption*)
- Exfoliative dermatitis (*Related to increased demand*)

- Hemolytic anemias (**Increased demand related to shortened RBC life span as the result of folate deficiency**)
- Liver disease (**Related to increased excretion**)
- Malnutrition (**Insufficient intake**)
- Megaloblastic anemia (**Folate deficiency affects development of the RBC and results in anemia**)
- Myelofibrosis (**Related to increased demand**)
- Neoplasms (**Related to increased demand**)
- Pregnancy (**Related to increased demand possibly combined with insufficient dietary intake**)
- Regional enteritis (**Related to malabsorption**)
- Scurvy (**Insufficient intake**)
- Sideroblastic anemias (**As an acquired anemia resulting from folate deficiency, iron enters and accumulates in the RBC but cannot become incorporated in hemoglobin**)
- Sprue (**Related to malabsorption**)
- Ulcerative colitis (**Related to malabsorption**)
- Whipple's disease (**Related to malabsorption**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may decrease folate levels include aminopterin, ampicillin, antacids, anticonvulsants, barbiturates, chloramphenicol, chloroguanide, erythromycin, ethanol, glutethimide, lincomycin, metformin, methotrexate, nitrofurans, oral contraceptives, penicillin, pentamidine, phenytoin, pyrimethamine, tetracycline, and triamterene.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to detect folate deficiency and to monitor folate therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal and hematopoietic systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. Protect the specimen from light.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for

bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Instruct the folate-deficient patient (especially pregnant women), as appropriate, to eat foods rich in folate, such as liver, salmon, eggs, asparagus, green leafy vegetables, broccoli, sweet potatoes, beans, and whole wheat.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be

performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies antithyroglobulin, biopsy intestinal, capsule endoscopy, complete blood count, complete blood count, RBC indices, complete blood count, RBC morphology, complete blood count, WBC count and differential, eosinophil count, fecal analysis, gastric acid emptying scan, gastric acid stimulation test, gastrin, G6PD, hemosiderin, homocysteine, intrinsic factor antibodies, thyroid and vitamin B₁₂.
- ▶ Refer to the Gastrointestinal and Hematopoietic System tables at the back of the book for related tests by body system.

F

Follicle-Stimulating Hormone

SYNONYM/ACRONYM: Follitropin, FSH.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Status	Conventional Units and SI Units
Prepuberty	Less than 10 international units/mL
Men	1.4–15.5 international units/mL
Women	
Follicular phase	1.4–9.9 international units/mL
Ovulatory peak	6.2–17.2 international units/mL
Luteal phase	1.1–9.2 international units/mL
Postmenopause	19–100 international units/mL

DESCRIPTION: Follicle-stimulating hormone (FSH) is produced and stored in the anterior portion of the pituitary gland. In women, FSH promotes maturation of the graafian (germinal) follicle, causing estrogen secretion and allowing the ovum to mature. In men, FSH partially controls spermatogenesis, but the presence of testosterone is also necessary. Gonadotropin-releasing hormone secretion is stimulated by a decrease in estrogen and testosterone levels. Gonadotropin-releasing hormone secretion stimulates FSH secretion. FSH production is inhibited by an increase in estrogen and testosterone levels. FSH production is pulsatile, episodic, and cyclic, and is subject to diurnal variation. Serial measurement is often required.

INDICATIONS:

- Assist in distinguishing between primary and secondary (pituitary or hypothalamic) gonadal failure
- Define menstrual cycle phases as a part of infertility testing
- Evaluate ambiguous sexual differentiation in infants
- Evaluate early sexual development in girls younger than age 9 or boys younger than age 10 (precocious puberty associated with elevated levels)
- Evaluate failure of sexual maturation in adolescence
- Evaluate testicular dysfunction
- Investigate impotence, gynecomastia, and menstrual disturbances

RESULT:

Increased in:

- Alcoholism (*Related to suppressed secretion from the pituitary gland*)

- Castration (*Oversecretion related to feedback mechanism involving decreased testosterone levels*)
- Gonadal failure (*Oversecretion related to feedback mechanism involving decreased estrogen or testosterone levels*)
- Gonadotropin-secreting pituitary tumors (*Related to oversecretion by tumor cells*)
- Klinefelter's syndrome (*Oversecretion related to feedback mechanism involving decreased estrogen or testosterone levels*)
- Menopause (*Oversecretion related to feedback mechanism involving decreased estrogen levels*)
- Orchitis (*Oversecretion related to feedback mechanism involving decreased testosterone levels*)
- Precocious puberty in children (*Related to oversecretion from the pituitary gland*)
- Primary hypogonadism (*Oversecretion related to feedback mechanism involving decreased estrogen or testosterone levels; failure of testes or ovaries to produce sex hormones*)
- Reifenstein's syndrome (*Oversecretion related to feedback mechanism involving familial partial resistance to testosterone levels*)
- Turner's syndrome (*Oversecretion related to feedback mechanism involving decreased estrogen or testosterone levels*)

Decreased in:

- Anorexia nervosa (*Related to suppressive effects of severe caloric restriction on the hypothalamic-pituitary axis*)
- Anterior pituitary hypofunction (*Underproduction resulting from dysfunctional pituitary gland*)

- Hemochromatosis (*Hypogonadotropic hypogonadism related to absence of the gonadal stimulating pituitary hormones, estrogen, and testosterone; iron deposits in pituitary may affect normal production of FSH*)
- Hyperprolactinemia (*Related to suppressive effect on estrogen production*)
- Hypothalamic disorders (*Decreased production in response to lack of hypothalamic stimulators*)
- Polycystic ovary disease (Stein-Leventhal syndrome) (*Suppressed secretion related to feedback mechanism involving increased estrogen levels*)
- Pregnancy (*Related to elevated estrogen levels*)
- Sickle cell anemia (*Although primary testicular dysfunction is mainly associated with sickle cell disease, related to testicular microinfarcts, hypogonadotropic hypogonadism has been reported in some men with sickle cell disease*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase FSH levels include cimetidine, clomiphene, digitalis, gonadotropin-releasing hormone, ketoconazole, levodopa, nafarelin, naloxone, nilutamide, oxcarbazepine, and pravastatin.
- Drugs that may decrease FSH levels include anabolic steroids, anticonvulsants, busserelin, estrogens, corticotropin-releasing hormone, goserelin, megestrol, mestranol, oral contraceptives, phenothiazine, pimozide, pravastatin, progesterone, stanozolol, tamoxifen, toremifene, and valproic acid.
- In menstruating women, values vary in relation to the phase

of the menstrual cycle. Values are higher in postmenopausal women.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Inform the patient that the test is used to distinguish primary causes of gonadal failure from secondary causes, evaluate menstrual disturbances, and assist in infertility evaluations.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and reproductive systems, as well as phase of menstrual cycle, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient

demographics, date, and time of collection. Perform a venipuncture.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Social and cultural considerations:** Recognize anxiety related to test results and provide a supportive, non-judgmental environment when assisting a patient through the process of fertility testing. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient and partner regarding access to counseling services, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that multiple specimens may be required. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies, antisperm, BMD, chlamydia group antibody, chromosome analysis, CT pituitary, estradiol, laparoscopy gynecologic, LH, MRI pituitary, prolactin, testosterone, semen analysis, and US scrotal.
- ▶ Refer to the Endocrine and Reproductive System tables at the back of the book for related tests by body system.

F

Fructosamine

SYNONYM/ACRONYM: Glycated albumin.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Spectrophotometry)

Status	Conventional Units	SI Units (Conventional Units × 0.01)
Normal	174–286 micromol/L	1.74–2.86 mmol/L
Diabetic		
<i>Controlled</i>	210–421 micromol/L	2.10–4.21 mmol/L
<i>Uncontrolled</i>	268–870 micromol/L	2.68–8.70 mmol/L

DESCRIPTION: Fructosamine is the result of a covalent linkage between glucose and albumin or other proteins. Similar to

glycated hemoglobin, fructosamine can be used to monitor long-term control of glucose in diabetics. It has a shorter half-life

than glycated hemoglobin and is thought to be more sensitive to short-term fluctuations in glucose concentrations. Some glycosylated hemoglobin methods are affected by hemoglobin variants. Fructosamine is not subject to this interference

INDICATIONS:

Evaluate diabetic control

RESULT:

Increased in:

Diabetic patients with poor glucose control

Decreased in:

Severe hypoproteinemia

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase fructosamine levels include bendroflumethiazide and captopril.
- Drugs that may decrease fructosamine levels include ascorbic acid, pyridoxine, and terazosin.
- Decreased albumin levels may result in falsely decreased fructosamine levels.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate diabetic control.
- ▶ Obtain a history of the patient's complaints, especially related to diabetic control. Obtain a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and gastrointestinal systems, symptoms, and results of

previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Abnormal fructosamine levels may be associated with conditions resulting from poor glucose control. Instruct the diabetic patient, as appropriate, in nutritional management of the disease. Patients who adhere to dietary recommendations report a better general feeling of health, better

weight management, greater control of glucose and lipid values, and improved use of insulin. There is no “diabetic diet”; however, many meal-planning approaches with nutritional goals are endorsed by the American Dietetic Association. The nutritional needs of each diabetic patient must be determined individually with the appropriate health care professionals, particularly professionals trained in nutrition.

- ▶ Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy).
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient’s lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Emphasize, as appropriate, that good control of glucose levels delays the onset and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient

regarding access to counseling services. Provide contact information, if desired, for the American Diabetes Association (www.diabetes.org)

- ▶ Reinforce information given by the patient’s HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient’s symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CT cardiac scoring, cortisol, C-peptide, fecal fat, fluorescein angiography, fundus photography, gastric emptying scan, glucagon, glucose, GTT, glycated hemoglobin, insulin, insulin antibodies, intraocular pressure, ketones, microalbumin, slit-lamp biomicroscopy, and visual fields testing.
- ▶ Refer to the Endocrine and Gastrointestinal System tables at the back of the book for related tests by body system.

F

Fundus Photography

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: This test involves the photographic examination of the structures of the eye to document the condition of the eye, detect abnormalities, and assist in following the progress of treatment.

INDICATIONS:

- Detect the presence of choroidal nevus
- Detect various types and stages of glaucoma
- Document the presence of diabetic retinopathy
- Document the presence of macular degeneration and any other

degeneration and any associated hemorrhaging

- Observe ocular effects resulting from the long-term use of high-risk medications

RESULT:

Normal findings in:

- Normal optic nerve and vessels
- No evidence of other ocular abnormalities

Abnormal findings in:

- Aneurysm
- Choroidal nevus
- Diabetic retinopathy
- Macular degeneration
- Obstructive disorders of the arteries or veins that lead to collateral circulation

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with narrow-angle glaucoma if pupil dilation is performed; dilation can initiate a severe and sight-threatening open-angle attack
- Patients with allergies to mydriatics if pupil dilation using mydriatics is performed

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the test because of age, significant pain, or mental status may interfere with the test results.
- Presence of cataracts may interfere with fundal view.
- Ineffective dilation of the pupils may impair clear imaging.
- Rubbing or squeezing the eyes may affect results.
- Failure to follow medication restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient the procedure detects possible vascular or other structural abnormalities of the eye.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially mydriatics if dilation is to be performed.
- ♦ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; and eye conditions with treatment regimens.
- ♦ Obtain a history of results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.
- ♦ Review the procedure with the patient. Explain that the patient will be requested to fixate the eyes during the procedure. Address concerns about pain and explain that mydriatics, if used, may cause blurred vision and sensitivity to light. There may also be a brief stinging sensation when the drop is put in the eye but that no discomfort will be experienced during the examination. Inform the patient that a health care provider (HCP) performs the test, in a quiet, darkened room, and that to dilate and evaluate both eyes, the test can take up to 60 min.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food or fluid restrictions, unless by medical direction.
- ♦ The patient should avoid eye medications (particularly mydriatic eye drops if the patient has glaucoma) for at least 1 day prior to the test.

- ▶ Ensure that the patient understands that he or she must refrain from driving until the pupils return to normal (about 4 hr) after the test and has made arrangements to have someone else be responsible for transportation after the test.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions; assure that eye medications, especially mydriatics, have been restricted for at least 1 day prior to the test.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still during the procedure because movement produces unreliable results.
- ▶ Seat the patient in a chair that faces the camera. Instruct the patient to look at directed target while the eyes are examined.
- ▶ If dilation is to be performed, administer the ordered mydriatic to each eye and repeat in 5 to 15 min. Drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semi-transparent area of the eyeball where the cornea and sclera meet). Neither dropper nor bottle should touch the eyelashes.
- ▶ Instruct the patient to place the chin in the chin rest and gently press the forehead against the support bar. Instruct the patient to open his or her eyes wide and look at desired target while a sequence of photographs are taken.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications, as directed by the HCP.
- ▶ Recognize anxiety related to test results, and be supportive of impaired

activity related to vision loss or anticipated loss of driving privileges. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide contact information regarding vision aids, if desired, for ABLEDATA (sponsored by the National Institute on Disability and Rehabilitation Research [NIDRR], available at www.abledata.com). Information can also be obtained from the American Macular Degeneration Foundation (www.macular.org) and the American Diabetes Association (www.diabetes.org).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that visual acuity and responses to light may change. Suggest that the patient wear dark glasses after the test until the pupils return to normal size. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include fluorescein angiography, fructosamine, glucose, glycated hemoglobin, gonioscopy, insulin, intraocular pressure, microalbumin, plethysmography, refraction, slit-lamp biomicroscopy, and visual field testing.
- ▶ Refer to the table of tests associated with the Ocular System at the back of the book for related tests by body system.

Gallium Scan

SYNONYM/ACRONYM: Ga; Gallium scan, tumor; gallium scan, abscess; gallium scan, fever of undetermined origin.

AREA OF APPLICATION: Whole body.

CONTRAST: IV radioactive gallium-67 citrate.

DESCRIPTION: Gallium imaging is a nuclear medicine study that assists in diagnosing neoplasm and inflammation activity. Gallium, which has 90% sensitivity for inflammatory disease, is readily distributed throughout plasma and body tissues. Gallium imaging is sensitive in detecting abscesses, pneumonia, pyelonephritis, active sarcoidosis, and active tuberculosis. In immunocompromised patients, such as patients with AIDS, gallium imaging can detect complications such as *Pneumocystis jiroveci* (formerly *carinii*) pneumonitis. Gallium imaging is useful but less commonly performed in the diagnosis and staging of some neoplasms, including Hodgkin's disease, lymphoma, melanoma, and leukemia. Imaging can be performed 6 to 72 hr after gallium injection. A gamma camera detects the radiation emitted from the injected radioactive material, and a representative image of the distribution of the radioactive material is obtained. The nonspecificity of gallium imaging requires correlation with other diagnostic studies, such as computed tomography, magnetic resonance imaging, and ultrasonography.

INDICATIONS:

- Aid in the diagnosis of infectious or inflammatory diseases
- Evaluate lymphomas

- Evaluate recurrent lymphomas or tumors after radiation therapy or chemotherapy
- Perform as a screening examination for fever of undetermined origin

RESULT:

Normal findings in:

- Normal distribution of gallium. Some localization of the radionuclide within the liver, spleen, bone, nasopharynx, lacrimal glands, breast, and bowel is expected.

Abnormal findings in:

- Abscess
- Infection
- Inflammation
- Lymphoma
- Tumor

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

- Performance of other nuclear scans within the preceding 24 to 48 hr
- Administration of certain medications (e.g., gastrin, cholecystokinin), which may interfere with gastric emptying

Other considerations:

- Improper injection of the radionuclide may allow the tracer to seep deep into the muscle tissue, producing erroneous hot spots.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test detects inflammation, infection, or tumor.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's immune, musculoskeletal, and respiratory systems, symptoms, and results of previously performed

laboratory tests and diagnostic and surgical procedures.

- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department, by a HCP specializing in this procedure, with support staff, and takes approximately 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into

the gown, robe, and foot coverings provided.

- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to lie still during the procedure because movement produces unclear images.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in a supine position on a flat table with foam wedges, which help maintain position and immobilization.
- ▶ IV radionuclide is administered and the patient is instructed to return for scanning at a designated time after injection. Typical scanning occurs at 6, 24, 48, 72, 96, and/or 120 hr postinjection depending on diagnosis.
- ▶ If an abdominal abscess or infection is suspected, laxatives or enemas may be ordered before imaging at 48 or 72 hr after the injection.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ Instruct the patient to resume usual medication, or activity, as directed by the HCP.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not

breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.

- ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 48 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash ungloved hands after removing the gloves.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiotensin converting enzyme, biopsy bone marrow, biopsy kidney, biopsy lung, blood gases, bronchoscopy, complete blood count, chest x-ray, CT abdomen, CT pelvis, CT thoracic, culture blood, culture and smear mycobacteria, culture viral, cytology sputum, cytology urine, ESR, HIV-1/2 antibodies, IVP, lung perfusion scan, MRI chest, MRI abdomen, mediastinoscopy, pleural fluid analysis, plethysmography, PFT, pulse oximetry, renogram, US kidney, and US lymph node.
- ▶ Refer to the Immune, Musculoskeletal, and Respiratory System tables in the back of the book for related tests by body system.

Gastric Acid Stimulation Test

SYNONYM/ACRONYM: N/A.

SPECIMEN: Gastric fluid collected in eight plastic tubes at 15-min intervals.

REFERENCE VALUE: (Method: Volume measurement and pH by ion-selective electrode)

Basal acid output (BAO)	<i>Male:</i> 0–10.5 mmol/hr <i>Female:</i> 0–5.6 mmol/hr
Peak acid output (PAO)	<i>Male:</i> 12–60 mmol/hr <i>Female:</i> 8–40 mmol/hr
Peak response time	<i>Pentagastrin, intramuscular:</i> 15–45 min <i>Pentagastrin, subcutaneous:</i> 10–30 min
BAO/PAO ratio	Less than 0.20

DESCRIPTION: The gastric acid stimulation test is performed to determine the response to substances administered to induce increased gastric acid production. Pentagastrin is the usual drug of choice to induce gastric secretion because it has no major side effects. The samples obtained from gastric acid stimulation tests are examined for volume, pH, and amount of acid secreted. First, basal acid output (BAO) is determined by averaging the results of gastric samples collected before the administration of a gastric stimulant. Then a gastric stimulant is administered and peak acid output (PAO) is determined by adding together the gastric acid output of the highest two consecutive 15-min stimulation samples. Finally, BAO and PAO are compared as a ratio, which is normally less than 0.20.

INDICATIONS:

- Detect duodenal ulcer
- Detect gastric carcinoma
- Detect pernicious anemia
- Detect Zollinger-Ellison syndrome
- Evaluate effectiveness of vagotomy in the treatment of peptic ulcer disease

RESULT:

Increased in:

Any alteration in the balance between the digestive and protective functions of the stomach that increases gastric acidity, e.g., hypersecretion of gastrin, use of NSAIDs or Helicobacter pylori infection.

Increased:

- BAO
 - Basophilic leukemia
 - Duodenal ulcer
 - G-cell hyperplasia
 - Recurring peptic ulcer
 - Retained antrum syndrome
 - Systemic mastocytosis

Vagal hyperfunction
Zollinger-Ellison syndrome

- PAO
Duodenal ulcer
Zollinger-Ellison syndrome

Decreased in:

Conditions that result in the gradual loss of function of the antrum and G-cells, where gastrin is produced, will reflect decreased gastrin levels.

Decreased:

- BAO
Gastric ulcer
- PAO
Chronic gastritis
Gastric cancers
Gastric polyps
Gastric ulcer
Myxedema
Pernicious anemia

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase gastric volume include atropine, diazepam, ganglionic blocking agents, and insulin.
- Drugs and substances that may increase gastric pH include caffeine, calcium salts, corticotropin, ethanol, rauwolfia, reserpine, and tolazoline.
- Drugs and substances that may decrease gastric pH include atropine, cimetidine, diazepam, famotidine, ganglionic blocking agents, glucagon, nizatidine, omeprazole, oxmetidine, propranolol, prostaglandin F_{2a}, ranitidine, and secretin.
- Gastric intubation is contraindicated in patients with esophageal varices, diverticula, stenosis, malignant neoplasm of the esophagus, aortic aneurysm, severe gastric hemorrhage, and congenital heart failure.
- The use of histamine diphosphate is contraindicated in patients with

a history of asthma, paroxysmal hypertension, urticaria, or other allergic conditions.

- Failure to follow dietary restrictions may result in stimulation of gastric secretions.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Exposure to the sight, smell, or thought of food immediately before and during the test may result in stimulation of gastric secretions.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the differential diagnosis of gastrointestinal disorders.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's gastrointestinal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 60 to 120 min. Address concerns about pain and explain that some discomfort is experienced from insertion of the nasogastric tube.
- ♦ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ Drugs and substances that may alter gastric secretions (e.g., alcohol, histamine, nicotine, adrenocorticotropic

steroids, insulin, parasympathetic agents, belladonna alkaloids, anticholinergic drugs, histamine receptor antagonists) should be restricted by medical direction for 72 hr before the test.

- ▶ Instruct the patient to fast from food after the evening meal the night before the test, and not to drink water for 1 hr before the test. Instruct the patient to refrain from the use of chewing gum or tobacco products for at least 12 hr prior to and for the duration of the test. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions and other pretesting preparations; assure that food has been restricted for at least 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Ensure that the patient does not have a history of asthma, paroxysmal hypertension, urticaria, or other allergic conditions if histamine diphosphate is being considered for use in the test.
- ▶ Record baseline vital signs.
- ▶ If the patient is wearing dentures, have him or her remove them.
- ▶ Ask the patient to sit, or help the patient recline on the left side.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date, and time of collection.
- ▶ A cold lubricated gastric (Levine) tube is inserted orally. Alternatively, if the patient has a hyperactive gag reflex, the tube can be inserted nasally. The tube must have a radiopaque tip.
- ▶ Fluoroscopy or x-ray is used to confirm proper position of the tube before the start of the test.

- ▶ Using a constant but gentle suction, gastric contents are collected. Do not use specimens obtained from the first 15 to 30 min of suctioning.
- ▶ The gastric stimulant is administered, and the peak basal specimens are collected over a 60-min period as four 15-min specimens. Number the specimen tubes in the order in which they were collected.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and medication, as directed by the HCP.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP for evaluation. Protocols may vary from facility to facility.
- ▶ Instruct the patient to report any chest pain, upper abdominal pain, pain on swallowing, difficulty breathing, or expectoration of blood. Report these to the HCP immediately.
- ▶ Monitor for side effects of drugs administered to induce gastric secretion (e.g., flushing, headache, nasal stuffiness, dizziness, faintness, nausea).
- ▶ **Nutritional considerations:** Nutritional support with calcium, iron, and vitamin B₁₂ supplementation may be ordered, as appropriate. Dietary modifications may include encouraging liquids and low-residue foods, eating multiple small meals throughout the day, and avoidance of foods that slow digestion such as foods high in fat and fiber. Severe cases of gastroparesis may require temporary treatments that include total parenteral nutrition or use of jejunostomy tubes.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and

determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include capsule endoscopy, complete blood count, esophagogastroduodenoscopy, fecal analysis, folate, gastric emptying scan, gastrin, *H. pylori* antibody, intrinsic factor antibodies, complete blood count, RBC indices, complete blood count, RBC morphology, upper GI series, vitamin B₁₂, and complete blood count, WBC count and differential.
- ▶ Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Gastric Emptying Scan

SYNONYM/ACRONYM: Gastric emptying quantitation, gastric emptying scintigraphy.

AREA OF APPLICATION: Esophagus, stomach, small bowel.

CONTRAST: Oral radioactive technetium-99m sulfur colloid.

DESCRIPTION: A gastric emptying scan quantifies gastric emptying physiology. The procedure is indicated for patients with gastric motility symptoms, including diabetic gastroparesis, anorexia nervosa, gastric outlet obstruction syndromes, postvagotomy and postgastroectomy syndromes, and assessment of medical and surgical treatments for diseases known to affect gastric motility. A radionuclide is administered, and the clearance of solids and liquids may be evaluated. The images are recorded electronically, showing the gastric emptying function over time.

INDICATIONS:

- Investigate the cause of rapid or slow rate of gastric emptying
- Measure gastric emptying rate

RESULT:

Normal findings in:

- Mean time emptying of liquid phase: 30 min (range, 11 to 49 min)
- Mean time emptying of solid phase: 40 min (range, 28 to 80 min)
- No delay in gastric emptying rate

Abnormal findings in:

- Decreased rate:
 - Dumping syndrome
 - Duodenal ulcer
 - Malabsorption syndromes
 - Zollinger-Ellison syndrome

- Increased rate:
 - Amyloidosis
 - Anorexia nervosa
 - Diabetes
 - Gastric outlet obstruction
 - Gastric ulcer
 - Gastroenteritis
 - Gastroesophageal reflux
 - Hypokalemia, hypomagnesemia
 - Post-gastric surgery period
 - Postoperative ileus
 - Post-radiation therapy period
 - Scleroderma

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Patients with esophageal motor disorders or swallowing difficulties

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Retained barium from a previous radiological procedure
- Other nuclear scans done within the previous 24 to 48 hr
- Administration of certain medications (e.g., gastrin, cholecystokinin), which may interfere with gastric emptying

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses gastric emptying.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's gastrointestinal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the

procedure is performed in a nuclear medicine department by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 120 min.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during and after the procedure.
- ▶ Instruct the patient to restrict food and fluids for 8 hr before the scan. Protocols may vary from facility to facility.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with dietary and fluid restrictions for 8 hr before the scan.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Record baseline vital signs and neurological status. Protocols may vary from facility to facility.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to lie still during the procedure because movement produces unclear images.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in an upright position in front of the gamma camera.
- ▶ Ask the patient to take the radionuclide mixed with water or other liquid orally, or combined with eggs for a solid study.
- ▶ Images are recorded over a period of time (30 to 60 min) and evaluated with regard to the amount of time the stomach takes to empty its contents.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.

- ▶ Advise the patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Tell the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ Monitor vital signs every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Instruct the patient to resume usual diet, fluids, medication, and activity, as directed by the HCP.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after removing the gloves.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include barium swallow, biopsy kidney, biopsy liver, biopsy lung,

calcitonin stimulation, calcium, capsule endoscopy, CT abdomen, esophageal manometry, EGD, fecal analysis, gastric acid stimulation, gastrin stimulation, GI blood loss scan, glucose, glycated hemoglobin, *Helicobacter*

pylori antibodies, liver and spleen scan, magnesium, PTH, UGI and small bowel series, and vitamin B₁₂.

Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Gastrin and Gastrin Stimulation Test

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

Age	Conventional Units	SI Units (Conventional Units × 1)
Infant	120–183 pg/mL	120–183 ng/L
Child	Less than 10–125 pg/mL	Less than 10–125 ng/L
Adult		
Up to 60 yr	25–90 pg/mL	25–90 ng/L
60 yr and older	Less than 100 pg/mL	Less than 100 ng/L

Stimulation Tests

Gastrin stimulation test with calcium or secretin

No response or slight increase over baseline

DESCRIPTION: Gastrin is a hormone secreted by the stomach and duodenum in response to vagal stimulation; the presence of food, alcohol, or calcium in the stomach; and the alkalinity of gastric secretions. After its absorption into the circulation, gastrin returns to the stomach and acts as a stimulant for acid, insulin, pepsin, and intrinsic factor secretion. Gastrin stimulation tests can be performed after a test meal or IV infusion of calcium or secretin.

INDICATIONS:

- Assist in the diagnosis of gastric carcinoma, pernicious anemia, or G-cell hyperplasia
- Assist in the diagnosis of Zollinger-Ellison syndrome
- Assist in the differential diagnosis of ulcers from other gastrointestinal (GI) peptic disorders

RESULT:

Increased in:

- Chronic gastritis (**Related to hypersecretion of gastrin, use of NSAIDs, or *Helicobacter pylori* infection.**)

- Chronic renal failure (*Related to inadequate renal excretion*)
- Gastric and duodenal ulcers (*Related to hypersecretion of gastrin, use of NSAIDs, or H. pylori infection.*)
- Gastric carcinoma (*Related to disturbance in pH favoring alkalinity, which stimulates gastrin production*)
- G-cell hyperplasia (*Hyperplastic G-cells produce excessive amounts of gastrin*)
- Hyperparathyroidism (*Related to hypercalcemia; calcium is a potent stimulator for the release of gastrin*)
- Pernicious anemia (*Related to antibodies against gastric intrinsic factor [66% of cases] and parietal cells [80% of cases that affect the stomach's ability to secrete acid; achlorhydria is a strong stimulator of gastrin production]*)
- Pyloric obstruction (*Related to gastric distension, which stimulates gastrin production*)
- Retained antrum (*Remaining tissue stimulates gastrin production*)
- Zollinger-Ellison syndrome (*Gastrin-producing tumor*)

Decreased in:

- Hypothyroidism (*Related to hypocalcemia*)
- Vagotomy (*Vagus nerve impulses stimulate secretion of digestive secretions; interruptions in these nerve impulses result in decreased gastrin levels*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may increase gastrin levels include amino acids, catecholamines, cimetidine, insulin, morphine, omeprazole, pantoprazole, sufofodine, terbutaline, calcium products, and coffee.

- Drugs that may decrease gastrin levels include atropine, enprostil, glucagon, secretin, streptozocin, and tolbutamide.
- In some cases, protein ingestion elevates serum gastrin levels.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.
- Failure to follow dietary and medication restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of Zollinger-Ellison syndrome and gastrinoma.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine and GI systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ Instruct the patient to fast for 12 hr before the test. Instruct the patient to refrain from the use of chewing gum or tobacco products for at least 4 hr

prior to and for the duration of the test. Protocols may vary from facility to facility.

- ▶ Instruct the patient to withhold medications and alcohol for 12 to 24 hr, as ordered by the health care provider (HCP).
- ▶ There are no fluid restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions and other pretesting preparations; assure that food and medications have been withheld for at least 4 and 12 hr, respectively prior to the procedure. The patient should be reminded to refrain from use of chewing gum or tobacco products during the test.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Administer gastrin stimulators as appropriate.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and medications, as directed by the HCP.

- ▶ **Nutritional considerations:** Nutritional support with calcium, iron, and vitamin B₁₂ supplementation may be ordered, as appropriate. Dietary modifications may include encouraging liquids and low-residue foods, eating multiple small meals throughout the day, and avoidance of foods that slow digestion such as foods high in fat and fiber. Severe cases of gastroparesis may require temporary treatments that include total parenteral nutrition or use of jejunostomy tubes.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in the significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include capsule endoscopy, complete blood count, complete blood count, RBC indices, complete blood count, RBC morphology, complete blood count, WBC count and differential, esophagogastroduodenoscopy, fecal analysis, folate, gastric acid stimulation test, gastric emptying scan, *H. pylori* antibody, intrinsic factor antibodies, upper GI series, and vitamin B₁₂.
- ▶ Refer to the Endocrine and Gastrointestinal System tables at the back of the book for related tests by body system.

Gastroesophageal Reflux Scan

SYNONYM/ACRONYM: Aspiration scan, GER scan, GERD scan.

AREA OF APPLICATION: Esophagus and stomach.

CONTRAST: Oral radioactive technetium-99m sulfur colloid.

DESCRIPTION: The gastroesophageal reflux (GER) scan assesses gastric reflux across the esophageal sphincter. Symptoms of GER include heartburn, regurgitation, vomiting, dysphagia, and a bitter taste in the mouth. This procedure may be used to evaluate the medical or surgical treatment of patients with GER and to detect aspiration of gastric contents into the lungs. A radionuclide such as technetium-99m sulfur colloid is ingested orally in orange juice. Scanning studies are done immediately to assess the amount of liquid that has reached the stomach. An abdominal binder is applied and then tightened gradually to obtain images at increasing degrees of abdominal pressure: 0, 20, 40, 60, 80, and 100 mm Hg. Computer calculation determines the amount of reflux into the esophagus at each of these abdominal pressures as recorded on the images. For aspiration scans, images are taken over the lungs to detect tracheoesophageal aspiration of the radionuclide.

In infants, the study distinguishes between vomiting and reflux. Reflux occurs predominantly in infants younger than age 2, who are mainly on a milk diet. This procedure is indicated when an infant has symptoms such as failure to thrive, feeding

problems, and episodes of wheezing with chest infection. The radionuclide is added to the infant's milk, images are obtained of the gastric and esophageal area, and the images are evaluated visually and by computer.

INDICATIONS:

- Aid in the diagnosis of GER in patients with unexplained nausea and vomiting
- Distinguish between vomiting and reflux in infants with failure to thrive, feeding problems, and wheezing combined with chest infection

RESULT:

Normal findings in:

- Reflux less than or equal to 4% across the esophageal sphincter

Abnormal findings in:

- Reflux of greater than 4% at any pressure level
- Pulmonary aspiration

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

- Patients with hiatal hernia, esophageal motor disorders, or swallowing difficulties

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings, dentures) within the examination field, which may inhibit organ visualization and cause unclear images
- Retained barium from a previous radiological procedure
- Other nuclear scans done within the previous 24 to 48 hr

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- Inform the patient that the procedure evaluates gastric reflux.

- Obtain a history of the patient's complaints, including a list of known allergens (especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes).
- Obtain a history of the patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- There are no food or fluid restrictions, unless by medical direction.
- *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- Have emergency equipment readily available.
- Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.

- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in an upright position and instruct them to ingest the radionuclide combined with orange juice.
- ▶ Place the patient in a supine position on a flat table 15 min after ingestion
- ▶ An abdominal binder with an attached sphygmomanometer is applied, and scans are taken as the binder is tightened at various pressures.
- ▶ If reflux occurs at lower pressures, an additional 30 mL of water may be given to clear the esophagus.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure. Monitor and administer an antiemetic agent if ordered. Ready an emesis basin for use.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
 - ▶ Advise the patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Tell the patient that radionuclide is eliminated from the body within 6 to 24 hr.
 - ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Compare with baseline values. Protocols may vary from facility to facility.
 - ▶ Instruct the patient to resume usual diet, fluids, medication, and activity, as directed by the HCP.
 - ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
 - ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
 - ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
 - ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes. High fat consumption increases the amount of bile acids in the colon and should be avoided.
 - ▶ Recognize anxiety related to test results, and be supportive of expected changes in lifestyle. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CT abdomen, esophageal manometry, gastric emptying scan, and upper GI series.
- ▶ Refer to the Gastrointestinal and Musculoskeletal System tables in the back of the book for related tests by body system.

Gastrointestinal Blood Loss Scan

SYNONYM/ACRONYM: Gastrointestinal bleed localization study, GI bleed scintigraphy, lower GI blood loss scan, GI scintigram.

AREA OF APPLICATION: Abdomen.

CONTRAST: IV radioactive technetium-99m-labeled red blood cells.

DESCRIPTION: Gastrointestinal (GI) blood loss scan is a nuclear medicine study that assists in detecting and localizing active GI tract bleeding (2 or 3 mL/min) for the purpose of better directing endoscopic or angiographic studies. This procedure can detect bleeding if the rate is greater than 0.5 mL/min, but it is not specific for site localization or cause of bleeding. Endoscopy is the procedure of choice for diagnosing upper GI bleeding. After injection of technetium-99m-labeled red blood cells, immediate and delayed images of various views of the abdomen are obtained. The radionuclide remains in the circulation long enough to extravasate and accumulate within the bowel lumen at the site of active bleeding. This procedure is valuable for the detection and localization of recent non-GI intra-abdominal hemorrhage. Images may be taken over an extended period to show intermittent bleeding.

INDICATIONS:

- Diagnose unexplained abdominal pain and GI bleeding

RESULT:

Normal findings in:

- Normal distribution of radionuclide in the large vessels with no extravascular activity

Abnormal findings in:

- Angiodysplasia
- Aortoduodenal fistula
- Diverticulosis
- GI bleeding
- Inflammatory bowel disease
- Polyps
- Tumor
- Ulcer

CRITICAL VALUES:

- Acute GI bleed
- Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Other nuclear scans done within the previous 24 to 48 hr
- Inaccurate timing of imaging after the radionuclide injection

Other considerations:

- The examination detects only active or intermittent bleeding.
- The procedure is of little value in patients with chronic anemia or slowly decreasing hematocrit.
- The scan is less accurate for localization of bleeding sites in the upper GI tract.
- Improper injection of the radionuclide allows the tracer to seep deep into the muscle tissue, producing erroneous hot spots.
- The test is not specific and does not indicate the exact pathological condition causing the bleeding, and may miss small sites of bleeding (less than 0.5 mL/min) caused by diverticular disease or angiodysplasia.
- Physiologically unstable patients may be unable to be scanned over long periods or may need to go to surgery before the procedure is complete.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure evaluates GI bleeding.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ♦ Obtain a history of the patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department by a HCP specializing in this procedure, with support staff, and takes approximately 60 min to complete, with additional images taken periodically over 24 hr.
- ♦ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives. Usually normal saline is infused.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.

- There are no food or fluid restrictions, unless by medical direction.
- Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- Have emergency equipment readily available.
- Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- Observe standard precautions, and follow the general guidelines in Appendix A.
- Administer a sedative to a child or to an uncooperative adult, as ordered.
- Establish IV fluid line for the injection of emergency drugs, radionuclide, and sedatives.
- Place the patient in a supine position on a flat table with foam wedges to help maintain position and immobilization.
- The radionuclide is administered IV and images are recorded immediately and every 5 min over a period of 60 min in various positions.
- The needle or catheter is removed, and a pressure dressing is applied over the puncture site.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Advise the patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Tell the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by

the HCP. Compare with baseline values. Protocols may vary from facility to facility.

- No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- Instruct the patient to resume usual diet, fluids, medication, and activity, as directed by the HCP.
- Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes. High fat consumption increases the amount of bile acids in the colon and should be avoided.
- Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include antibodies antineutrophilic cytoplasmic,

angiography abdomen, barium enema, barium swallow, cancer antigens, capsule endoscopy, colonoscopy, complete blood count, CT abdomen, EGD, fecal analysis, IgA, MRI abdomen, Meckel's diverticulum scan, proctosigmoidoscopy, upper GI series, and WBC scan.

Refer to the Gastrointestinal and Hematopoietic System tables in the back of the book for related tests by body system.

G

Glucagon

SYNONYM/ACRONYM: N/A.

SPECIMEN: Plasma (1 mL) collected in chilled, lavender-top (EDTA) tube. Specimen should be transported tightly capped and in an ice slurry.

REFERENCE VALUE: (Method: Radioimmunoassay)

Age	Conventional Units	SI Units (Conventional Units × 1)
Cord blood	0–215 pg/mL	0–215 ng/L
1–3 d	0–1750 pg/mL	0–1750 ng/L
4–14 yr	0–148 pg/mL	0–148 ng/L
Adult	20–100 pg/mL	20–100 ng/L

DESCRIPTION: Glucagon is a hormone secreted by the alpha cells of the islets of Langerhans in the pancreas in response to hypoglycemia. This hormone acts primarily on the liver to promote glucose production from glycogen stores and to control glycogen storage. Glucagon also produces glucose from the oxidation of fatty acids like triglycerides to basic glycerol components. The coordinated release of insulin, glucagon, and somatostatin ensures an adequate fuel supply while maintaining stable blood

glucose. Patients with glucagonoma have values greater than 500 ng/L. Values greater than 1000 ng/L are diagnostic for this condition. Glucagonoma causes three different syndromes:

Syndrome 1: A characteristic skin rash, diabetes or impaired glucose tolerance, weight loss, anemia, and venous thrombosis

Syndrome 2: Severe diabetes

Syndrome 3: Multiple endocrine neoplasia

A dramatic increase in glucagon occurring soon after renal

transplant may indicate organ rejection. In the case of kidney transplant rejection, glucagon levels increase several days before an increase in creatinine levels.

Glucagon deficiency can be confirmed by measuring glucagon levels before and after IV infusion of arginine 0.5 g/kg. Glucagon deficiency is confirmed when levels fail to rise 30 to 60 min after infusion. Newborn infants of diabetic mothers have impaired glucagon secretion, which may play a role in their hypoglycemia.

INDICATIONS:

- Assist in confirming glucagon deficiency
- Assist in the diagnosis of suspected glucagonoma (alpha islet-cell neoplastic tumor)
- Assist in the diagnosis of suspected renal failure or renal transplant rejection

RESULT:

Increased in:

Glucagon is produced in the pancreas and excreted by the kidneys; conditions that affect the pancreas and cause cellular destruction or conditions that impair the ability of the kidneys to remove glucagon from circulation will result in elevated glucagon levels.

- Acromegaly (**Growth hormone stimulates production of glucagon**)
- Acute pancreatitis
- Burns (**Stress-induced release of catecholamines stimulates glucagon production**)
- Cirrhosis (**Pathophysiology is not well established**)
- Cushing's syndrome (**Overproduction of cortisol stimulates glucagon production**)

- Diabetes (uncontrolled) (**Pathophysiology is not well established**)
- Glucagonoma
- Hyperlipoproteinemia (**Pathophysiology is not well established**)
- Hypoglycemia (**Produced in response to decreased glucose level**)
- Infection (**Related to feedback loop in response to stress**)
- Kidney transplant rejection
- Pheochromocytoma (**Excessive production of catecholamines stimulates increased glucagon levels**)
- Renal failure
- Stress (**Catecholamines released during stressful periods stimulate production of glucagon**)
- Trauma (**Stress-induced release of catecholamines stimulates glucagon production**)

Decreased in:

Related to decreased pancreatic function.

- Chronic pancreatitis
- Cystic fibrosis
- Postpancreatectomy period

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase glucagon levels include amino acids (e.g., arginine), cholecystokinin, danazol, gastrin, glucocorticoids, insulin, and nifedipine.
- Drugs that may decrease glucagon levels include atenolol, pindolol, propranolol, secretin, and verapamil.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of glucagonoma.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to fast for at least 12 hr before specimen collection for baseline values. Diabetic patients should be in good glycemic control before testing.
- ▶ Prepare an ice slurry in a cup or plastic bag to have ready for immediate transport of the specimen to the laboratory. Prechill the lavender-top tube in the ice slurry.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the

patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a chilled tube. The sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ **Nutritional considerations:** Instruct the diabetic patient, as appropriate, in nutritional management of the disease. Patients who adhere to dietary recommendations report a better general feeling of health, better weight management, greater control of glucose and lipid values, and improved use of insulin. There is no "diabetic diet"; however, many meal-planning approaches with nutritional goals are endorsed by the American Dietetic Association. The nutritional needs of each diabetic patient must be determined individually with the appropriate health care professionals, particularly professionals trained in nutrition.
- ▶ Increased glucagon levels may be associated with diabetes. Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy).
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical

implications of the test results, as appropriate. Emphasize, as appropriate, that good glycemic control delays the onset and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Diabetes Association (www.diabetes.org).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography adrenal, catecholamines, cholangiopancreatography endoscopic retrograde, CT cardiac scoring, CT pancreas, CT renal, C peptide, gastric emptying scan, glucose, GTT, glycated hemoglobin, GH, HVA, insulin, insulin antibodies, MRI pancreas, metanephrines, microalbumin, peritoneal fluid analysis, and US pancreas.
- ▶ Refer to the Endocrine System table at the end of the book for related tests by body system.

Glucose

SYNONYM/ACRONYM: Blood sugar, fasting blood sugar (FBS), postprandial glucose, 2-hr PC.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in gray-top (sodium fluoride) or green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Radioimmunoassay)

Age	Conventional Units	SI Units (Conventional Units × 0.0555)
	<i>Fasting</i>	
Cord blood	45–96 mg/dL	2.5–5.3 mmol/L
Premature infant	20–60 mg/dL	1.1–3.3 mmol/L
Neonate	30–60 mg/dL	1.7–3.3 mmol/L
Newborn 1 d	40–60 mg/dL	2.2–3.3 mmol/L
Newborn 2 d–2 yr	50–80 mg/dL	2.8–4.4 mmol/L
Child	60–100 mg/dL	3.3–5.6 mmol/L
Adult	65–99 mg/dL	3.6–5.5 mmol/L
<i>Prediabetes or Impaired Fasting Glucose</i>	100–125 mg/dL	5.6–6.9 mmol/L
	<i>2-Hr Postprandial</i>	
2-hr Postprandial	Less than 105 mg/dL	Less than 5.8 mmol/L
	<i>Random</i>	
Random	Less than 200 mg/dL	Less than 11.1 mmol/L

ADA-recommended treatment goal for FBG is less than 120 mg/dL.

DESCRIPTION: Glucose, a simple six-carbon sugar (monosaccharide), enters the diet as part of the sugars sucrose, lactose, and maltose and as the major constituent of the complex polysaccharide called dietary starch. The body acquires most of its energy from the oxidative metabolism of glucose. Excess glucose is stored in the liver or in muscle tissue as glycogen.

Diabetes is a group of diseases characterized by hyperglycemia or elevated glucose levels. Hyperglycemia results from a defect in insulin secretion (type 1 diabetes), a defect in insulin action, or a combination of defects in secretion and action (type 2 diabetes). The chronic hyperglycemia of diabetes may result over time in damage, dysfunction, and eventually failure of the eyes, kidneys, nerves, heart, and blood vessels. The American Diabetes Association's criteria for diagnosing diabetes include any combination of the following findings or confirmation of any of the individual findings by repetition on a subsequent day:

- Symptoms of diabetes (e.g., polyuria, polydipsia, unexplained weight loss) in addition to a random glucose level greater than 200 mg/dL
- Fasting blood glucose greater than 126 mg/dL, after a minimum of an 8-hr fast
- Glucose level greater than 200 mg/dL 2 hr after glucose challenge with standardized 75-mg load

INDICATIONS:

- Assist in the diagnosis of insulinoma
- Determine insulin requirements
- Evaluate disorders of carbohydrate metabolism
- Identify hypoglycemia
- Screen for diabetes

RESULT:

Increased in:

- Acromegaly, gigantism (*GH stimulates the release of glucagon, which in turn increases glucose levels*)
- Acute stress reaction (*Hyperglycemia is stimulated by the release of catecholamines and glucagon*)
- Cerebrovascular accident (*Possibly related to stress*)
- Cushing's syndrome (*Related to elevated cortisol*)
- Diabetes (*Glucose intolerance and elevated glucose levels define diabetes*)
- Glucagonoma (*Glucagon releases stored glucose; glucagon-secreting tumors will increase glucose levels*)
- Hemochromatosis (*Related to iron deposition in the pancreas; subsequent damage to pancreatic tissue releases cell contents including glucagon, resulting in hyperglycemia*)
- Liver disease (severe) (*Damaged liver tissue releases cell contents into circulation including stored glucose*)
- Myocardial infarction (*Related to stress and/or pre-existing diabetes*)
- Pancreatic adenoma (*Damage to pancreatic tissue releases cell contents including glucagon, resulting in hyperglycemia*)
- Pancreatitis (acute and chronic) (*Damage to pancreatic tissue releases cell contents including glucagon, resulting in hyperglycemia*)
- Pancreatitis due to mumps (*Damage to pancreatic tissue releases cell contents including glucagon, resulting in hyperglycemia*)
- Pheochromocytoma (*Related to increased catecholamines, which increase glucagon; glucagon increases glucose levels*)

- Renal disease (severe) (*Glucagon is degraded by the kidneys; when damaged kidneys cannot metabolize glucagon, glucagon levels in blood rise and result in hyperglycemia*)
- Shock, trauma (*Hyperglycemia is stimulated by the release of catecholamines and glucagon*)
- Somatostatinoma (*Somatostatin-producing tumor of pancreatic delta cells, associated with diabetes*)
- Strenuous exercise (*Hyperglycemia is stimulated by the release of catecholamines and glucagon*)
- Syndrome X (metabolic syndrome) (*Related to the development of diabetes*)
- Thyrotoxicosis (*Related to loss of kidney function*)
- Vitamin B₁ deficiency (*Thiamine is involved in the metabolism of glucose; deficiency results in accumulation of glucose*)

Decreased in:

- Acute alcohol ingestion (*Most glucose metabolism occurs in the liver; alcohol inhibits the liver from making glucose*)
- Addison's disease (*Cortisol affects glucose levels; insufficient levels of cortisol result in diminished glucose levels*)
- Ectopic insulin production from tumors (adrenal carcinoma, carcinoma of the stomach, fibrosarcoma)
- Excess insulin by injection
- Galactosemia (*Inherited enzyme disorder that results in accumulation of galactose in excessive proportion to glucose levels*)
- Glucagon deficiency (*Glucagon controls glucose levels; hypoglycemia occurs in the absence of glucagon*)
- Glycogen storage diseases (*Deficiencies in enzymes involved in conversion of glycogen to glucose*)
- Hereditary fructose intolerance (*Inherited disorder of fructose metabolism; phosphates needed for intermediate steps in gluconeogenesis are trapped from further action by the enzyme deficiency responsible for fructose metabolism*)
- Hypopituitarism (*Decreased levels of hormones such as ACTH and GH result in decreased glucose levels*)
- Hypothyroidism (*Thyroid hormones affect glucose levels; decreased thyroid hormone levels result in decreased glucose levels*)
- Insulinoma (*The function of insulin is to decrease glucose levels*)
- Malabsorption syndromes (*Insufficient absorption of carbohydrates*)
- Maple syrup urine disease (*Inborn error of amino acid metabolism; accumulation of leucine is believed to inhibit the rate of gluconeogenesis, independently of insulin, and thereby diminish release of hepatic glucose stores*)
- Poisoning resulting in severe liver disease (*Decreased liver function correlates with decreased glucose metabolism*)
- Postgastrectomy (*Insufficient intake of carbohydrates*)
- Starvation (*Insufficient intake of carbohydrates*)
- von Gierke disease (*Most common glycogen storage disease; G6PD deficiency*)

CRITICAL VALUES:

Less than 40 mg/dL

Greater than 400 mg/dL

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

Glucose monitoring is an important measure in achieving tight glycemic control. The enzymatic GDH-PQQ test method may produce falsely elevated results in patients who are receiving products that contain other sugars (e.g., oral xylose, parenterals containing maltose or galactose, and peritoneal dialysis solutions that contain icodextrin). The GDH-NAD, glucose oxidase, and glucose hexokinase methods are capable of distinguishing between glucose and other sugars.

Symptoms of decreased glucose levels include headache, confusion, hunger, irritability, nervousness, restlessness, sweating, and weakness. Possible interventions include oral or IV administration of glucose, IV or intramuscular injection of glucagon, and continuous glucose monitoring.

Symptoms of elevated glucose levels include abdominal pain, fatigue, muscle cramps, nausea, vomiting, polyuria, and thirst. Possible interventions include subcutaneous or IV injection of insulin with continuous glucose monitoring.

INTERFERING FACTORS:

- Drugs that may increase glucose levels include acetazolamide, alanine, albuterol, anesthetic agents, antipyrine, atenolol, betamethasone, cefotaxime, chlorpromazine, chlorprothixene, clonidine, clorexolone, corticotropin, cortisone, cyclic AMP, cyclopropane, dexamethasone, dextroamphetamine, diamide, epinephrine, enflurane, ethacrynic acid, ether, fludrocortisone, fluoxymesterone, furosemide, glucagon, glucocorticoids, homoharringtonine, hydrochlorothiazide, hydroxydione, isoniazid, maltose, meperidine, meprednisone, methyclothiazide, metolazone, niacin, nifedipine, nortriptyline, octeotide, oral contraceptives, oxyphenbutazone, pancreozymin, phenelzine, phenylbutazone, piperacetazine,

polythiazide, prednisone, quinethazone, reserpine, rifampin, ritodrine, salbutamol, secretin, somatostatin, thiazides, thyroid hormone, and triamcinolone.

- Drugs that may decrease glucose levels include acarbose, acetylsalicylic acid, acipimox, alanine, allopurinol, antimony compounds, arsenicals, ascorbic acid, benzene, buformin, cannabis, captopril, carbutamide, chloroform, clofibrate, dexfenfluramine, enalapril, enprostil, erythromycin, fenfluramine, gemfibrozil, glibornuride, glyburide, guanethidine, niceritrol, nitrazepam, oral contraceptives, oxandrolone, oxymetholone, phentolamine, phosphorus, promethazine, ramipril, rotenone, sulfonyleureas, thiocarbide, tolbutamide, tromethamine, and verapamil.
- Elevated urea levels and uremia can lead to falsely elevated glucose levels.
- Extremely elevated white blood cell counts can lead to falsely decreased glucose values.
- Failure to follow dietary restrictions before the fasting test can lead to falsely elevated glucose values.
- Administration of insulin or oral hypoglycemic agents within 8 hr of a fasting blood glucose can lead to falsely decreased values.
- Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, falsely decreasing the result. There is also the potential of contaminating the sample with the substance of interest, if it is present in the IV solution, falsely increasing the result.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Inform the patient that the test is used to assist in the diagnosis of diabetes and to evaluate disorders of carbohydrate metabolism.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of medications the patient is taking, including herbs, nutritional supplements, nutraceuticals, insulin, and any other substances used to regulate glucose levels.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ For the fasting glucose test, the patient should fast for at least 12 hr before specimen collection.
- ▶ The patient should follow the instructions given for 2-hr postprandial glucose test. Some HCP's may order administration of a standard glucose solution, whereas others may instruct the patient to eat a meal with a known carbohydrate composition.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions and other pretesting preparations; assure that food has been restricted for at least 12 hr prior to the fasting procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid

the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ *Nutritional considerations:* Increased glucose levels may be associated with diabetes. Instruct the diabetic patient, as appropriate, in nutritional management of the disease. Patients who adhere to dietary recommendations report a better general feeling of health, better weight management, greater control of glucose and lipid values, and improved use of insulin. There is no "diabetic diet"; however, many meal-planning approaches with nutritional goals are endorsed by the American Dietetic Association. The nutritional needs of each diabetic patient must be determined individually with the appropriate health care professionals, particularly professionals trained in nutrition.
- ▶ Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy).

- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Emphasize, as appropriate, that good glycemic control delays the onset of and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Diabetes Association (www.diabetes.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, angiography adrenal, BUN, calcium, catecholamines, cholesterol (HDL, LDL, total), cortisol, C-peptide, CT cardiac scoring, CRP, CK and isoenzymes, creatinine, DHEA, echocardiography, fecal analysis, fecal fat, fluorescein angiography, fructosamine, fundus photography, gastric emptying scan, GTT, glycated hemoglobin A_{1C}, gonioscopy, Holter monitor, HVA, insulin, insulin antibodies, ketones, LDH and isoenzymes, lipoprotein electrophoresis, MRI chest, metanephrines, microalbumin, myoglobin, MI infarct scan, myocardial perfusion heart scan, PET heart, renin, sodium, troponin, and visual fields test.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Glucose-6-Phosphate Dehydrogenase

SYNONYM/ACRONYM: G6PD.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Fluorescent) Qualitative assay—enzyme activity detected; quantitative assay—the following table reflects enzyme activity in units per gram of hemoglobin:

Age	Conventional Units	SI Units
	<i>(Conventional Units × 0.0645)</i>	
Newborn	7.8–14.4 international units/g hemoglobin	0.5–0.93 micro units/mol hemoglobin
Adult	5.5–9.3 international units/g hemoglobin	0.35–0.60 micro units/mol hemoglobin

DESCRIPTION: Glucose-6-phosphate dehydrogenase (G6PD) is a red blood cell enzyme. It is involved in the hexose monophosphate shunt, and its function is to protect hemoglobin from oxidation. G6PD deficiency is an inherited X-linked abnormality; approximately 20% of female carriers are heterozygous. This deficiency results in hemolysis of varying degrees and acuity depending on the severity of the abnormality. There are three G6PD variants of high frequency in different ethnic groups. G6PD A- is more common in African-Americans (10% of males). G6PD Mediterranean is especially common in Iraqis, Kurds, Sephardic Jews, and Lebanese and less common in Greeks, Italians, Turks, North Africans, Spaniards, Portuguese, and Ashkenazi Jews. G6PD Mahidol is common in Southeast Asians (22% of males).

INDICATIONS:

- Assist in identifying the cause of hemolytic anemia resulting from drug sensitivity, metabolic disorder, or infection
- Assist in identifying the cause of hemolytic anemia resulting from enzyme deficiency

RESULT:

Increased in:

The pathophysiology is not well understood but release of the enzymes from hemolyzed cells increases blood levels.

- Hepatic coma
- Hyperthyroidism (**Possible response to increased basal metabolic rate and role of G6PD in glucose metabolism**)

- Idiopathic thrombocytopenic purpura
- Myocardial infarction (**Medications given, e.g., salicylates, may aggravate or stimulate a hemolytic crisis in G6PD-deficient patients**)
- Pernicious anemia
- Viral hepatitis

Decreased in:

- Congenital nonspherocytic anemia
- G6PD deficiency
- Nonimmunological hemolytic disease of the newborn

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Sulfates may decrease G6PD levels.
- G6PD levels are increased in reticulocytes; the test results may be falsely positive when a patient is in a period of acute hemolysis. G6PD levels can also be affected by the presence of large numbers of platelets and white blood cells, which also contain significant amounts of the enzyme.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify an enzyme deficiency that can result in red blood cell hemolysis.
- ▶ Obtain a history of the patient's complaints, including a list of known

allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations:* Educate the patient with G6PD deficiency, as appropriate, to avoid certain foods, vitamins, and drugs that may precipitate an acute episode of intravascular hemolysis, including fava beans, ascorbic acid (large doses), acetanilid, antimalarials, furazolidone, isobutyl nitrate, methylene blue, nalidixic acid, naphthalene, niridazole, nitrofurantoin, phenazopyridine, phenylhydrazine, primaquine, sulfacetamide, sulfamethoxazole, sulfanilamide, sulfapyridine, thiazolesulfone, toluidine blue, trinitrotoluene, and urate oxidase.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, bilirubin, complete blood count, complete blood count, RBC morphology (including examination of peripheral smear for the presence of Heinz bodies), direct antiglobulin test, folate, Ham's test, haptoglobin, hemosiderin, osmotic fragility, reticulocyte count, UA, and vitamin B₁₂.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Glucose Tolerance Tests

SYNONYM/ACRONYM: Standard oral tolerance test, standard gestational screen, standard gestational tolerance test, GTT.

SPECIMEN: Plasma (1 mL) collected in gray-top (sodium fluoride) tube. Serum (1 mL) collected in a red- or tiger-top tube or plasma collected in a green-top (heparin) tube is also acceptable. It is important to use the same type of collection container throughout the entire test.

REFERENCE VALUE: (Method: Spectrophotometry)

	Conventional Units	SI Units (Conventional Units × 0.0555)
Standard Oral Tolerance		
Fasting sample	Less than 126 mg/dL	Less than 7.0 mmol/L
2-hr sample	Less than 200 mg/dL	Less than 11.1 mmol/L
Prediabetes or Impaired Glucose Tolerance	140–199 mg/dL	7.8–11.0 mmol/L
<i>Tolerance Tests for Gestational Diabetes</i>		
Standard Gestational Screen	Less than 141 mg/dL	Less than 7.8 mmol/L
Standard Gestational Tolerance		
Fasting sample	75–104 mg/dL	4.2–5.8 mmol/L
1-hr sample	75–180 mg/dL	4.2–10.0 mmol/L
2-hr sample	75–164 mg/dL	4.2–9.1 mmol/L
3-hr sample	75–144 mg/dL	4.2–8.0 mmol/L

Plasma glucose values are reported to be 10%–20% higher than serum values.

DESCRIPTION: The glucose tolerance test (GTT) measures glucose levels after administration of an oral or IV carbohydrate challenge. Patients with diabetes are unable to metabolize glucose at a normal rate. The oral GTT is used for individuals who are able to eat and who are not known to have problems with gastrointestinal malabsorption. The IV GTT is used for individuals who are unable to tolerate oral glucose.

Diabetes is a group of diseases characterized by

hyperglycemia or elevated glucose levels. Hyperglycemia results from a defect in insulin secretion (type 1 diabetes), a defect in insulin action, or a combination of dysfunction secretion and action (type 2 diabetes). The chronic hyperglycemia of diabetes over time results in damage, dysfunction, and eventually failure of the eyes, kidneys, nerves, heart, and blood vessels. The American Diabetes Association's criteria for diagnosing diabetes include any combination of the following findings or confirmation of any

of the individual findings by repetition on a subsequent day:

- Symptoms of diabetes (e.g., polyuria, polydipsia, and unexplained weight loss) in addition to a random glucose level greater than 200 mg/dL
- Fasting blood glucose greater than 126 mg/dL, after a minimum of an 8-hr fast
- Glucose level greater than 200 mg/dL 2 hr after glucose challenge with standardized 75-mg load

INDICATIONS:

- Evaluate abnormal fasting or postprandial blood glucose levels that do not clearly indicate diabetes
- Evaluate glucose metabolism in women of childbearing age, especially women who are pregnant and have (1) a history of previous fetal loss or birth of infants weighing 9 pounds or more, and/or (2) a family history of diabetes
- Identify abnormal renal tubular function if glycosuria occurs without hyperglycemia
- Identify impaired glucose metabolism without overt diabetes
- Support the diagnosis of hyperthyroidism and alcoholic liver disease, which are characterized by a sharp rise in blood glucose followed by a decline to subnormal levels

RESULT:

Tolerance increased in:

- Decreased absorption of glucose:
 - Adrenal insufficiency (Addison's disease, hypopituitarism)
 - Hypothyroidism
 - Intestinal diseases, such as celiac disease and tropical sprue
 - Whipple's disease
- Increased insulin secretion:
 - Pancreatic islet cell tumor

Tolerance impaired in:

- Increased absorption of glucose:
 - Excessive intake of glucose
 - Gastrectomy
 - Gastroenterostomy
 - Hyperthyroidism
 - Vagotomy
- Decreased usage of glucose:
 - Central nervous system lesions
 - Cushing's syndrome
 - Diabetes
 - Hemochromatosis
 - Hyperlipidemia
- Decreased glycogenesis:
 - Hyperthyroidism
 - Infections
 - Liver disease (severe)
 - Pheochromocytoma
 - Pregnancy
 - Stress
 - von Gierke disease

CRITICAL VALUES:

Less than 40 mg/dL

Greater than 400 mg/dL

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

Symptoms of decreased glucose levels include headache, confusion, hunger, irritability, nervousness, restlessness, sweating, and weakness. Possible interventions include oral or IV administration of glucose, IV or intramuscular injection of glucagon, and continuous glucose monitoring.

Symptoms of elevated glucose levels include abdominal pain, fatigue, muscle cramps, nausea, vomiting, polyuria, and thirst. Possible interventions include subcutaneous or IV injection of insulin with continuous glucose monitoring.

INTERFERING FACTORS:

- Drugs and substances that may increase GTT values include acetylsalicylic acid, atenolol, bendroflumethiazide, caffeine, clofibrate, fenfluramine, fluoxymesterone,

glyburide, guanethidine, lisinopril, methandrostenolone, metoprolol, nandrolone, niceritrol, nifedipine, nitrendipine, norethisterone, phenformin, phenobarbital, prazosin, and terazosin.

- Drugs and substances that may decrease GTT values include acebutolol, beclomethasone, bendroflumethiazide, betamethasone, calcitonin, catecholamines, chlorothiazide, chlorpromazine, chlorthalidone, cimetidine, corticotropin, cortisone, danazol, deflazacort, dexamethasone, diapamide, diethylstilbestrol, ethacrynic acid, fludrocortisone, furosemide, glucagon, glucocorticosteroids, heroin, hydrochlorothiazide, mephenytoin, mestranol, methadone, methandrostenolone, methylprednisolone, muzolimine, niacin, nifedipine, norethindrone, norethy nodrel, oral contraceptives, paramethasone, perphenazine, phenolphthalein, phenothiazine, phenytoin, pindolol, prednisolone, prednisone, propranolol, quinethazone, thiazides, triamcinolone, triamterene, and verapamil.
- The test should be performed on ambulatory patients. Impaired physical activity can lead to falsely increased values.
- Excessive physical activity before or during the test can lead to falsely decreased values.
- Failure of the patient to ingest a diet with sufficient carbohydrate content (e.g., 150 g/day) for at least 3 days before the test can result in falsely decreased values.
- The patient may have difficulty drinking the extremely sweet glucose beverage and become nauseous. Vomiting during the course of the test will cause the test to be canceled.
- Smoking before or during the test can lead to falsely increased values.
- The patient should not be under recent or current physiological

stress during the test. If the patient has had recent surgery (less than 2 wk previously), an infectious disease, or a major illness (e.g., myocardial infarction), the test should be delayed or rescheduled.

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of diabetes.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Inform the patient that multiple specimens may be required. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ The patient should fast for at least 8 to 12 hr before the standard oral and standard gestational GTTs.
- ▶ There are no fluid or medication restrictions, unless by medical direction prior to the gestational screen.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and activity restrictions as well as other pretesting preparations; assure that food has been restricted

for at least 8 to 12 hr prior to the procedure.

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. Do not wait until all specimens have been collected to transport.

Standard Oral GTT:

- ▶ The standard oral GTT takes 2 hr. A fasting blood glucose is determined before administration of an oral glucose load. If the fasting blood glucose is less than 126 mg/dL, the patient is given an oral glucose load.
- ▶ An oral glucose load should not be administered *before* the value of the fasting specimen has been received. *If the fasting blood glucose is greater than 126 mg/dL, the standard glucose load is not administered and the test is canceled.* The laboratory will follow its protocol as far as notifying the patient of his or her glucose level and the reason why the test was canceled. The requesting HCP will then be issued a report indicating the glucose level and the cancellation of the test. A fasting glucose greater than 126 mg/dL indicates diabetes; therefore, the glucola would never be administered before allowing the requesting HCP to evaluate the clinical situation.
- ▶ Adults receive 75 g and children receive 1.75 g/kg ideal weight, not to exceed 75 g. The glucose load should be consumed within 5 min, and time 0 begins as soon as the patient begins to ingest the glucose load. A second specimen is collected at 2 hr,

concluding the test. The test is discontinued if the patient vomits before the second specimen has been collected.

Standard Gestational Screen:

- ▶ The standard gestational screen is performed on pregnant women. If results from the screen are abnormal, a full gestational GTT is performed. The gestational screen does not require a fast. The patient is given a 50-g oral glucose load. The glucose load should be consumed within 5 min, and time 0 begins as soon as the patient begins to ingest the glucose load. A specimen is collected 1 hr after ingestion. The test is discontinued if the patient vomits before the 1-hr specimen has been collected.

Standard Gestational GTT:

- ▶ The standard gestational GTT takes 3 hr. A fasting blood glucose is determined before administration of a 100-g oral glucose load. If the fasting blood glucose is less than 126 mg/dL, the patient is given an oral glucose load.
- ▶ An oral glucose load should not be administered *before* the value of the fasting specimen has been received. *If the fasting blood glucose is greater than 126 mg/dL, the glucola is not administered and the test is canceled* (see previous explanation).
- ▶ The glucose load should be consumed within 5 min, and time 0 begins as soon as the patient begins to ingest the glucose load. Subsequent specimens are collected at 1, 2, and 3 hr, concluding the test. The test is discontinued if the patient vomits before all specimens have been collected.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and activity, as directed by the HCP.
- ▶ **Nutritional considerations:** Increased glucose levels may be associated with diabetes. Instruct the diabetic patient, as appropriate, in nutritional management of the disease. Patients who adhere to dietary recommendations report a better general feeling of

health, better weight management, greater control of glucose and lipid values, and improved use of insulin. There is no “diabetic diet”; however, many meal-planning approaches with nutritional goals are endorsed by the American Dietetic Association. The nutritional needs of each diabetic patient need to be determined individually with the appropriate health care professionals, particularly professionals trained in nutrition.

- ▶ Impaired glucose tolerance may be associated with diabetes. Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy).
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient’s lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Emphasize, as appropriate, that good glycemic control delays the onset of and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient regarding access to counseling services. Provide contact information, if

desired, for the American Diabetes Association (www.diabetes.org).

- ▶ Reinforce information given by the patient’s HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient’s symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, ALP, antibodies gliadin, angiography adrenal, biopsy intestinal, biopsy thyroid, BUN, C-peptide, capsule endoscopy, catecholamines, cholesterol (total and HDL), cortisol, creatinine, DHEAS, fecal fat, folate, fructosamine, gastric acid stimulation, gastrin stimulation, glucagon, glucose, glycosylated hemoglobin, 5-HIAA, insulin, insulin antibodies, ketones, metanephrines, microalbumin, oxalate, RAIU, thyroid scan, TSH, thyroxine, triglycerides, and VMA.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

γ -Glutamyltransferase

SYNONYM/ACRONYM: Serum γ -glutamyltransferase, γ -glutamyl transpeptidase, GGT, SGGT.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

Gender	Conventional & SI Units
Male	2–30 units/L
Female	1–24 units/L

DESCRIPTION: Glutamyltransferase (GGT) assists with the reabsorption of amino acids and peptides from the glomerular filtrate and intestinal lumen. Hepatobiliary, renal tubular, and pancreatic tissues contain large amounts of GGT. Other sources include the prostate gland, brain, and heart. GGT is elevated in all types of liver disease and is more responsive to biliary obstruction, cholangitis, or cholecystitis than any of the other enzymes used as markers for liver disease.

INDICATIONS:

- Assist in the diagnosis of obstructive jaundice in neonates
- Detect the presence of liver disease
- Evaluate and monitor patients with known or suspected alcohol abuse (levels rise after ingestion of small amounts of alcohol)

RESULT:

Increased in:

GGT is released from any damaged cell in which it is stored so conditions that affect the liver, kidneys, or pancreas and cause cellular destruction demonstrate elevated GGT levels.

- Cirrhosis
- Diabetes with hypertension
- Hepatitis
- Hepatobiliary tract disorders
- Hepatocellular carcinoma
- Hyperthyroidism (**There is a strong association with concurrent liver abnormalities**)
- Infectious mononucleosis
- Obstructive liver disease
- Pancreatitis
- Renal transplantation
- Significant alcohol ingestion

Decreased in:

- Hypothyroidism (**Related to decreased enzyme production by the liver**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase GGT levels include acetaminophen, aminoglutethimide, anticonvulsants, barbiturates, captopril, clotiazepam, disulfiram, methyl-dopa, oral contraceptives, phenothiazines, rifampin, and streptokinase.
- Drugs that may decrease GGT levels include bezafibrate, cefotaxime, clofibrate, fenofibrate, and ursodiol.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess liver function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a history of IV drug use, alcohol use, high-risk sexual activity, and occupational exposure.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that

specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Increased GGT levels may be associated with liver disease. Dietary recommendations may be indicated and vary depending on the condition and its severity. Currently, there are no specific medications that can be given to cure hepatitis, but elimination of alcohol ingestion and a diet optimized for convalescence are commonly included in the treatment plan. A high-calorie,

high-protein, moderate-fat diet with a high fluid intake is often recommended for patients with hepatitis. Treatment of cirrhosis is different because a low-protein diet may be in order if the patient's liver has lost the ability to process the end products of protein metabolism. A diet of soft foods also may be required if esophageal varices have developed. Ammonia levels may be used to determine whether protein should be added to or reduced from the diet. The patient should be encouraged to eat simple carbohydrates and emulsified fats (as in homogenized milk or eggs), as opposed to complex carbohydrates (e.g., starch, fiber, and glycogen [animal carbohydrates]) and complex fats, which require additional bile to emulsify them so that they can be used. The cirrhotic patient should also be carefully observed for the development of ascites, in which case fluid and electrolyte balance requires strict attention. The alcoholic patient should be encouraged to avoid alcohol and to seek appropriate counseling for substance abuse.

- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to lack of neuromuscular control, perceived loss of independence, and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include ALT, ALP ammonia, AST, bilirubin, cholangiography percutaneous transhepatic, electrolytes, HAV antibody, HBV antigen and antibody, HCV antibody,

hepatobiliary scan, infectious mono screen, KUB studies, liver and spleen scan, MRI liver, TSH, and US liver. Refer to the Hepatobiliary System table at the back of the book for related tests by body system.

Glycated Hemoglobin

SYNONYM/ACRONYM: Hemoglobin A_{1C}, A_{1C}.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Chromatography)

Total A ₁	4.0–7.0%
A _{1C}	4.0–5.5%

Values vary widely by method. ADA-recommended treatment goal for hemoglobin A_{1C} is less than 7%.

DESCRIPTION: *Glycosylated* or *glycated hemoglobin* is a term used to describe the combination of glucose and hemoglobin into a ketamine; the rate at which this occurs is proportional to glucose concentration. The average life span of a red blood cell (RBC) is approximately 120 days; measurement of glycated hemoglobin is a way to monitor long-term diabetic management. The average plasma glucose can be estimated using the formula:

$$\text{Average plasma glucose (mg/dL)} = [(A_{1C} \times 35.6) - 77.3]$$

For example an A_{1C} value of 6% would reflect an average plasma

glucose of 136.3 mg/dL or $[(6 \times 35.6) - 77.3]$.

Diabetes is a group of diseases characterized by hyperglycemia or elevated glucose levels. Hyperglycemia results from a defect in insulin secretion (type 1 diabetes), a defect in insulin action, or a combination of dysfunctional secretion and action (type 2 diabetes). The chronic hyperglycemia of diabetes over time results in damage, dysfunction, and eventually failure of the eyes, kidneys, nerves, heart, and blood vessels. Hemoglobin A_{1C} levels are not age dependent and are not affected by exercise, diabetic medications, or nonfasting state before specimen collection.

INDICATIONS:

Assess long-term glucose control in diabetics

RESULT:**Increased in:**

- Diabetes (poorly controlled or uncontrolled) (*Related to and reflective of elevated glucose levels*)

Decreased in:

- Chronic blood loss (*Blood loss decreases concentration of RBC-bound glycated hemoglobin*)
- Chronic renal failure (*Low RBC count associated with this condition reflects corresponding decrease in RBC bound glycated hemoglobin*)
- Conditions that decrease RBC life span (*Low RBC count reflects corresponding decrease in RBC-bound glycated hemoglobin*)
- Hemolytic anemia (*Low RBC count due to hemolysis reflects corresponding decrease in RBC-bound glycated hemoglobin*)
- Pregnancy (*Low RBC associated with pregnancy reflects corresponding decrease in RBC-bound glycated hemoglobin*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase glycated hemoglobin A_{1C} values include hydrochlorothiazide, indapamide, insulin, morphine, propranolol, and sulfonyleureas.
- Drugs that may decrease glycated hemoglobin A_{1C} values include carbamate, galactose, and metformin.
- Conditions involving abnormal hemoglobins (hemoglobinopathies) affect the reliability of glycated hemoglobin A_{1C} values, causing (1) falsely increased

values, (2) falsely decreased values, or (3) discrepancies in either direction depending on the method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess long-term glycemic control (past 3 mo).
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally

and to avoid unnecessary movement.

- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ **Nutritional considerations:** Increased glycated hemoglobin A_{1C} levels may be associated with diabetes. Instruct the diabetic patient, as appropriate, in nutritional management of the disease. Patients who adhere to dietary recommendations report a better general feeling of health, better weight management, greater control of glucose and lipid values, and improved use of insulin. There is no “diabetic diet”; however, many meal-planning approaches with nutritional goals are endorsed by the American Dietetic Association. The nutritional needs of each diabetic patient must be determined individually with the appropriate health care professionals, particularly professionals trained in nutrition.
- ◆ Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy).
- ◆ Recognize anxiety related to test results, and be supportive of perceived

loss of independence and fear of shortened life expectancy.

- ◆ Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Emphasize, as appropriate, that good glycemic control delays the onset of and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Diabetes Association (ADA) (www.diabetes.org). The ADA recommends A_{1C} testing 4 times a yr for insulin-dependent type 1 or type 2 diabetes and twice a yr for non-insulin-dependent type 2 diabetes.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient in the use of FDA approved home test kits, if prescribed. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include C-peptide, cholesterol (total and HDL), CT cardiac scoring, creatinine/eGFR, EMG, ENG, fluorescein angiography, fructosamine, fundus photography, gastric emptying scan, glucagon, glucose, glucose tolerance tests, insulin, insulin antibodies, ketones, microalbumin, plethysmography, slit-lamp biomicroscopy, triglycerides, and visual fields test.
- ◆ Refer to the Endocrine System table at the back of the book for related tests by body system.

Gonioscopy

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: Gonioscopy is a technique used for examination of the anterior chamber structures of the eye, i.e., the trabecular meshwork and the anatomic relationship of the trabecular meshwork to the iris. The trabecular meshwork is the drainage system of the eye, and gonioscopy is performed to determine if it is suspected that the drainage angle may be damaged, blocked, or clogged. Gonioscopy in combination with biomicroscopy is considered to be the most thorough basis to confirm a diagnosis of glaucoma and to differentiate between open-angle and angle-closure glaucoma. The angle structures of the anterior chamber are normally not visible because light entering the eye through the cornea is reflected back into the anterior chamber. Placement of a special contact lens (goniolen) over the cornea allows reflected light to pass back through the cornea and onto a reflective mirror in the contact lens. It is in this way that the angle structures can be visualized. There are two types of gonioscopy; indirect and direct. The more commonly used indirect technique employs a mirrored goniolen and biomicroscope.

Direct gonioscopy is performed with a gonioscope containing a dome-shaped contact lens known as a gonioprism. The gonioprism eliminates internally reflected light, allowing direct visualization of the angle. Interpretation of visual examination is usually documented in a colored hand-drawn diagram. Scheie's classification is used to standardize definition of angles based on appearance by gonioscopy. Shaffer's classification is based on the angular width of the angle recess.

INDICATIONS:

- Assessment of peripheral anterior synechiae (PAS)
- Conditions affecting the ciliary body
- Degenerative conditions of the anterior chamber
- Evaluation of glaucoma (confirmation of normal structures and estimation of angle width)
- Growth or tumor in the angle
- Hyperpigmentation
- Post-trauma evaluation for angle recession
- Suspected neovascularization of the angle
- Uveitis

RESULT:**Scheie's Classification Based on Visible Angle Structures**

<i>Classification</i>	<i>Appearance</i>
Wide Open	All angle structures seen
Grade I Narrow	Difficult to see over the iris root
Grade II Narrow	Ciliary band obscured
Grade III Narrow	Posterior trabeculum hazy
Grade IV Narrow	Only Schwalbe's line visible

Shaffer's Classification Based on Angle Width

<i>Classification</i>	<i>Appearance</i>
Wide Open (20°–45°)	Closure improbable
Moderately Narrow (10°–20°)	Closure possible
Extremely Narrow (less than 10°)	Closure possible
Partially/Totally Closed	Closure present

Normal findings in:

- Normal appearance of anterior chamber structures and wide, unblocked, normal angle

Abnormal findings in:

- Corneal endothelial disorders (Fuchs endothelial dystrophy, iridocorneal endothelial syndrome)
- Glaucoma
- Lens disorders (cataract, displaced lens)
- Malignant ocular neoplasm in angle
- Neovascularization in angle
- Ocular hemorrhage
- PAS
- Schwartz syndrome
- Trauma
- Tumors
- Uveitis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Inability of the patient to cooperate or remain still during the test because of age, significant pain, or mental status may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient the procedure detects abnormalities in the structures of the anterior chamber of the eye.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; and eye surgery; as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Instruct the patient to remove contact lenses or glasses, as appropriate.
- ♦ Instruct the patient regarding the importance of keeping the eyes open for the test.
- ♦ Review the procedure with the patient. Explain that the patient will be requested

to fixate the eyes during the procedure. Address concerns about pain related to the procedure. Explain to the patient that no pain will be experienced during the test, but there may be moments of discomfort. Explain to the patient that some discomfort may be experienced after the test when the numbness wears off from anesthetic drops administered prior to the test. Inform the patient that the test is performed by a health care provider (HCP) or optometrist specially trained to perform this procedure and takes about 5 min to complete.

- ◆ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ◆ Seat the patient comfortably. Instill ordered topical anesthetic in each eye, as ordered, and allow time for it to work. Topical anesthetic drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semi-transparent area of the eyeball where the cornea and sclera meet). Neither the dropper nor the bottle should touch the eyelashes.
- ◆ Ask the patient to place the chin in the chin rest and gently press the forehead

against the support bar. Ask the patient to open his or her eyes wide and look at desired target. Explain that the HCP or optometrist will place a lens on the eye while a narrow beam of light is focused on the eye.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Recognize anxiety related to test results, and be supportive of impaired activity related to vision loss or anticipated loss of driving privileges. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include fundus photography, pachymetry, slit-lamp biomicroscopy, and visual field testing.
- ◆ Refer to the Ocular System table at the back of the book for related tests by body system.

Gram Stain

SYNONYM/ACRONYM: N/A.

SPECIMEN: Blood, biopsy specimen, or body fluid as collected for culture.

REFERENCE VALUE: N/A.

DESCRIPTION: Gram stain is a technique commonly used to identify bacterial organisms based on their specific staining characteristics. The method involves smearing a small amount of specimen on a slide, and then exposing it to gentian or crystal violet, iodine, alcohol, and safranin O. Gram-positive bacteria retain the gentian or crystal violet and iodine stain complex after a decolorization step and appear purple-blue in color. Gram-negative bacteria do not retain the stain after decolorization but can pick up the pink color of the safranin O counterstain. Gram stain results should be correlated with culture results to interpret the significance of isolated organisms. A sputum Gram stain showing greater than 25 squamous epithelial cells per low-power field, regardless of the

number of polymorphonuclear white blood cells, indicates contamination of the specimen with saliva, and the specimen should be rejected for subsequent culture. The occasional presence of bacteria in an unspun urine Gram stain suggests a correlating colony count of 10,000 bacteria/mL. The presence of bacteria in most fields is clinically significant and suggests greater than 100,000 bacteria/mL of urine.

INDICATIONS:

- Provide a rapid determination of the acceptability of the specimen for further analysis
- Provide rapid, presumptive information about the type of potential pathogen present in the specimen (i.e., gram-positive bacteria, gram-negative bacteria, or yeast)

RESULT:

Gram Positive

<i>Actinomadura</i>	<i>Actinomyces</i>	<i>Bacillus</i>	<i>Clostridium</i>	<i>Corynebacterium</i>
<i>Enterococcus</i>	<i>Erysipelothrix</i>	<i>Lactobacillus</i>	<i>Listeria</i>	<i>Micrococcus</i>
<i>Mycobacterium</i> (gram variable)	<i>Peptostreptococcus</i>	<i>Propionibacterium</i>	<i>Rhodococcus</i>	<i>Staphylococcus</i>
<i>Streptococcus</i>				

Gram Negative

<i>Acinetobacter</i>	<i>Aeromonas</i>	<i>Alcaligenes</i>	<i>Bacteroides</i>	<i>Bordetella</i>
<i>Borrelia</i>	<i>Brucella</i>	<i>Campylobacter</i>	<i>Citrobacter</i>	<i>Chlamydia</i>
<i>Enterobacter</i>	<i>Escherichia</i>	<i>Flavobacter</i>	<i>Francisella</i>	<i>Fusobacterium</i>
<i>Gardnerella</i>	<i>Haemophilus</i>	<i>Helicobacter</i>	<i>Klebsiella</i>	<i>Legionella</i>
<i>Leptospira</i>	<i>Moraxella</i>	<i>Neisseria</i>	<i>Pasteurella</i>	<i>Plesiomonas</i>
<i>Porphyromonas</i>	<i>Prevotella</i>	<i>Proteus</i>	<i>Pseudomonas</i>	<i>Rickettsia</i>
<i>Salmonella</i>	<i>Serratia</i>	<i>Shigella</i>	<i>Vibrio</i>	<i>Xanthomonas</i>
<i>Yersinia</i>				

Acid Fast or Partial Acid Fast

<i>Nocardia</i>	<i>Mycobacterium</i>
-----------------	----------------------

Note: *Treponema* species are classified as gram-negative spirochetes, but they are most often visualized using dark-field or silver staining techniques.

CRITICAL VALUES: 

- Note and immediately report to the health care provider (HCP) any positive results in blood, cerebrospinal fluid, or any body cavity fluid, along with related symptoms.

INTERFERING FACTORS:

- Very young, very old, or dead cultures may react atypically to the Gram stain technique.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in identifying the presence of pathogenic organisms.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal, genitourinary, immune, reproductive, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedure.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that the time it takes to collect a proper specimen varies according to the patient's level of cooperation as well as the specimen collection site. Address concerns about pain and explain to the patient that there may be some discomfort during the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
- ▶ Specific collection instructions are found in the associated culture monographs.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Administer antibiotics as ordered, and instruct the patient in the importance of completing the entire course of antibiotic therapy even if no symptoms are present.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amniotic fluid analysis, relevant biopsies, bronchoscopy, cultures bacterial and viral, CSF analysis, complete blood count, pericardial fluid analysis, peritoneal fluid analysis, pleural fluid analysis, synovial fluid analysis, and UA.
- ▶ Refer to the Gastrointestinal, Genitourinary, Immune, Reproductive, and Respiratory System tables at the back of the book for related tests by body system.

Group A Streptococcal Screen

SYNONYM/ACRONYM: Strep screen, rapid strep screen, direct strep screen.

SPECIMEN: Throat swab (two swabs should be submitted so that a culture can be performed if the screen is negative).

REFERENCE VALUE: (Method: Enzyme immunoassay or latex agglutination) Negative.

DESCRIPTION: Rheumatic fever is a possible sequela to an untreated streptococcal infection. Early diagnosis and treatment appear to lessen the seriousness of symptoms during the acute phase and overall duration of the infection and sequelae. The onset of strep throat is sudden and includes symptoms such as chills, headache, sore throat, malaise, and exudative gray-white patches on the tonsils or pharynx. The group A streptococcal screen should not be ordered unless the results would be available within 1 to 2 hr of specimen collection to make rapid, effective therapeutic decisions. A positive result can be a reliable basis for the initiation of therapy. A negative result is presumptive for infection and should be backed up by culture results. In general, specimens showing growth of less than 10 colonies on culture yield negative results by the rapid screening method. Evidence of group A streptococci disappears rapidly after the initiation of antibiotic therapy. A nucleic acid probe method has also been developed for rapid detection of group A streptococci.

INDICATIONS:

Assist in the rapid determination of the presence of group A streptococci

RESULT:

Positive findings in:

- Rheumatic fever
- Scarlet fever
- Strep throat
- Streptococcal glomerulonephritis
- Tonsillitis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Polyester (rayon or dacron) swabs are favored over cotton for best chance of detection. Fatty acids are created on cotton fibers during the sterilization process. Detectable target antigens on the streptococcal cell wall are destroyed without killing the organism when there is contact between the specimen and the fatty acids on the cotton collection swab. False-negative test results can be obtained on specimens collected with cotton tip swabs. Negative strep screens should always be followed with a traditional culture.
- Sensitivity of the method varies from manufacturer to manufacturer.
- Adequate specimen collection in children may be difficult to achieve, which explains the higher percentage of false-negative results in this age group.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to detect group A streptococcal infection.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a history of prior antibiotic therapy.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Before specimen collection, verify with the laboratory whether wet or dry swabs are preferred for collection.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the swabbing procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate specimen container with the corresponding patient demographics, date, and time of collection. Vigorous swabbing of both tonsillar pillars and the posterior throat enhances the probability of streptococcal antigen detection.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Administer antibiotics as ordered, and emphasize to the patient or caregiver the importance of completing the entire course of antibiotic therapy even if no symptoms are present.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related laboratory tests include analgesic and antipyretic drugs, antibiotic drugs, ASO, chest x-ray, complete blood count, culture (throat, viral), and gram stain.
- ▶ Refer to the Immune and Respiratory System tables at the back of the book for related tests by body system.

Growth Hormone, Stimulation and Suppression Tests

SYNONYM/ACRONYM: Somatotrophic hormone, somatotropin, GH, hGH.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: Method: Radioimmunoassay)

Growth Hormone

Age	Conventional Units	SI Units (Conventional Units × 1)
Cord blood	8–40 ng/mL	8–40 mcg/L
1 d	5–50 ng/mL	5–50 mcg/L
1 wk	5–25 ng/mL	5–25 mcg/L
Child	2–10 ng/mL	2–10 mcg/L
Adult		
<i>Male</i>	0–5 ng/mL	0–5 mcg/L
<i>Female</i>	0–10 ng/mL	0–10 mcg/L
<i>Male older than 60 yr</i>	0–10 ng/mL	0–10 mcg/L
<i>Female older than 60 yr</i>	0–14 ng/mL	0–14 mcg/L
	Stimulation Tests	
<i>Rise above baseline</i>	Greater than 5 ng/mL	Greater than 5 mcg/L
<i>Peak response</i>	Greater than 10 ng/mL	Greater than 10 mcg/L
	Suppression Tests	
	0–2 ng/mL	0–2 mcg/L

DESCRIPTION: Human growth hormone (GH) is secreted in episodic bursts by the anterior pituitary gland; the highest level is usually secreted during deep sleep. Release of GH is modulated by three hypothalamic factors: GH-releasing hormone, GH-releasing peptide-6, and GH inhibitory hormone (also known as somatostatin). The effects of GH are carried out by insulin-like growth factors, formerly called somatomedins. GH plays an integral role in growth from birth to puberty. GH promotes skeletal growth by stimulating

hepatic production of proteins; it also affects lipid and glucose metabolism. Random levels are rarely useful because secretion of GH is episodic and pulsatile. Stimulation tests with arginine, glucagon, insulin, or L-dopa, as well as suppression tests with glucose, provide useful information.

INDICATIONS:

- Assist in the diagnosis of acromegaly in adults
- Assist in establishing a diagnosis of dwarfism or growth retardation in

children with decreased GH levels, indicative of a pituitary cause

- Assist in establishing a diagnosis of gigantism in children with GH increased levels, indicative of a pituitary cause
- Detect suspected disorder associated with decreased GH
- Monitor response to treatment of growth retardation

RESULT:

Increased in:

Production of GH is modulated by numerous factors including stress, exercise, sleep, nutrition, and response to circulating levels of GH.

- Acromegaly
- Anorexia nervosa
- Cirrhosis
- Diabetes (uncontrolled)
- Ectopic GH secretion (neoplasms of stomach, lung)
- Exercise
- Gigantism (pituitary)
- Hyperpituitarism
- Laron dwarfism
- Malnutrition
- Renal failure
- Stress

Decreased in:

- Adrenocortical hyperfunction (**Inhibits secretion of GH**)
- Dwarfism (pituitary) (**Related to GH deficiency**)
- Hypopituitarism (**Related to lack of production**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase GH levels include alanine, anabolic steroids, angiotensin II, apomorphine, arginine, clonidine, corticotropin, cyclic AMP, desipramine, dexamethasone, dopamine, fenfluramine, galanin, glucagon, GH-releasing hormone, hydrazine, levodopa, methamphetamine, methyl dopa,

metoclopramide, midazolam, niacin, oral contraceptives, phenytoin, propranolol, and vasopressin.

- Drugs that may decrease GH levels include corticosteroids, corticotropin, hydrocortisone, octreotide, and pirenzepine.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.
- Failure to follow dietary and activity restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess pituitary function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record pertinent information related to diet, sleep pattern, and activity at the time of the test.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. The patient should have bed rest for 1 hr before each sample is obtained. Inform the patient that multiple specimens may be required. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

◆ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

◆ The patient should fast and avoid strenuous exercise for 12 hr before specimen collection. Protocols may vary from facility to facility.

INTRATEST:

◆ Ensure that the patient has complied with dietary and activity restrictions; assure that food and strenuous activity have been restricted for at least 12 hr prior to the procedure.

◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. Test samples may be requested at baseline and 10-, 20-, 30-, 45-, and 60-min intervals after stimulation and at baseline and 30-, 60-, 90-, and 120-min intervals after suppression.

◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

◆ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.

◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

◆ A related test is ACTH.

◆ Refer to the Endocrine System table at the back of the book for related tests by body system.

Ham's Test for Paroxysmal Nocturnal Hemoglobinuria

SYNONYM/ACRONYM: Acid hemolysis test for PNH.

SPECIMEN: Whole blood (5 mL) collected in lavender-top (EDTA) tube and serum (3 mL) collected in red-top tube.

REFERENCE VALUE: (Method: Acidified hemolysis) No hemolysis seen.

RESULT:

Decreased in: N/A

Increased in:

- Congenital dyserythropoietic anemia, type II
- PNH

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Haptoglobin

H

SYNONYM/ACRONYM: Hapto, HP, Hp.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Nephelometry)

Age	Conventional Units	SI Units (Conventional Units × 0.01)
Newborn	5–48 mg/dL	0.05–0.48 g/L
6 mo–16 yr	25–138 mg/dL	0.25–1.38 g/L
Adult	15–200 mg/dL	0.15–2.00 g/L

DESCRIPTION: Haptoglobin is an α_2 -globulin produced in the liver. It binds with the free hemoglobin released when red blood cells (RBCs) are lysed. If left unchecked, free hemoglobin in the plasma can cause renal damage; haptoglobin prevents it from accumulating. In conditions such as hemolytic anemia, so many hemolyzed RBCs are available for binding that the liver cannot

compensate by producing additional haptoglobin fast enough, resulting in low serum levels.

INDICATIONS:

- Assist in the investigation of suspected transfusion reaction
- Evaluate known or suspected chronic liver disease, as indicated by decreased levels of haptoglobin

- Evaluate known or suspected disorders characterized by excessive RBC hemolysis, as indicated by decreased levels of haptoglobin
- Evaluate known or suspected disorders involving a diffuse inflammatory process or tissue destruction, as indicated by elevated levels of haptoglobin

RESULT:**Increased in:**

- Biliary obstruction
- Disorders involving tissue destruction, such as cancers, burns, and acute myocardial infarction
- Infection or inflammatory diseases, such as ulcerative colitis, arthritis, and pyelonephritis
- Neoplasms
- Steroid therapy

Decreased in:

- Autoimmune hemolysis
- Hemolysis due to drug reaction
- Hemolysis due to mechanical destruction (e.g., artificial heart valves, contact sports, subacute bacterial endocarditis)
- Hemolysis due to RBC membrane or metabolic defects
- Hemolysis due to transfusion reaction
- Hypersplenism
- Ineffective hematopoiesis due to conditions such as folate deficiency or hemoglobinopathies
- Liver disease

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase haptoglobin levels include anabolic steroids, danazol, ethylestrenol, fluoxymesterone, methandrostenolone, norethandrolone, oxandrolone, oxymetholone, and stanozolol.
- Drugs that may decrease haptoglobin levels include acetanilid, aminosaliclic acid,

chlorpromazine, dapson, dextran, diphenhydramine, furadaltone, furazolidone, isoniazid, nitrofurantoin, norethindrone, oral contraceptives, quinidine, resorcinol, stibophen, tamoxifen, thiazolsulfone, and tripeleppamine.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to investigate hemolytic states.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic, hepatobiliary, and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate

tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to immediately report symptoms of hemolysis, including chills, fever, flushing, back pain, and fast heartbeat, to the HCP.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.

Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, AST, bilirubin, blood group and type, complete blood count, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology, Coombs' antiglobulin, folate, G6PD, GGT, Ham's test, hepatobiliary scan, and osmotic fragility.
- ▶ Refer to the Hematopoietic, Hepatobiliary, and Immune System tables at the back of the book for related tests by body system.

Helicobacter Pylori Antibody

SYNONYM/ACRONYM: *H. pylori*.

SPECIMEN: Serum (1 mL) collected in a plain red-top tube.

REFERENCE VALUE: (Method: Enzyme-linked immunosorbent assay [ELISA]) Negative.

DESCRIPTION: There is a strong association between *Helicobacter pylori* infection and gastric cancer, duodenal and gastric ulcer, and chronic gastritis. Immunoglobulin G (IgG) antibodies can be detected for up to 1 yr after treatment. The presence of *H. pylori* can also be demonstrated by a positive urea

breathe test, positive stool culture, or positive endoscopic biopsy. Patients with symptoms and evidence of *H. pylori* infection are considered to be *infected* with the organism; patients who demonstrate evidence of *H. pylori* but are without symptoms are said to be *colonized*.

INDICATIONS:

- Assist in differentiating between *H. pylori* infection and NSAID use as the cause of gastritis or peptic or duodenal ulcer
- Assist in establishing a diagnosis of gastritis, gastric carcinoma, or peptic or duodenal ulcer

RESULT:**Positive findings in:**

- *H. pylori* infection
- *H. pylori* colonization

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that a positive test result constitutes an independent risk factor for gastric cancer. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include capsule endoscopy, EGD, gastric acid stimulation, gastric emptying scan, gastrin, and upper GI series.
- ▶ Refer to the Gastrointestinal and Immune System tables at the back of the book for related test by body system.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of *H. pylori* infection in patients with duodenal and gastric disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

Hemoglobin Electrophoresis

SYNONYM/ACRONYM: N/A.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Electrophoresis)

Adult	<i>Hgb A</i> Greater than 95%
Adult	<i>Hgb A₂</i> 1.5–3.7%
	<i>Hgb F</i>
Newborns and infants	
1 d–3 wk	70–77%
6–9 wk	42–64%
3–4 mo	7–39%
6 mo	3–7%
8–11 mo	0.6–2.6%
Adult	Less than 2%

DESCRIPTION: Hemoglobin (Hgb) electrophoresis is a separation process used to identify normal and abnormal forms of Hgb. Hgb A is the main form of Hgb in the normal adult. Hgb F is the main form of Hgb in the fetus, the remainder being composed of Hgb A₁ and A₂. Small amounts of Hgb F are normal in the adult. Hgb D, E, H, S, and C result from abnormal amino acid substitutions during the formation of Hgb and are inherited hemoglobinopathies.

INDICATIONS:

- Assist in the diagnosis of Hgb C disease
- Assist in the diagnosis of thalassemia, especially in patients with a family history positive for the disorder

- Differentiate among thalassemia types
- Evaluate hemolytic anemia of unknown cause
- Evaluate a positive sickle cell screening test to differentiate sickle cell trait from sickle cell disease

RESULT:

Increased in:

- Hgb A₂:
Megaloblastic anemia
Thalassemias
- Hgb F:
Acquired aplastic anemia
Hereditary persistence of fetal Hgb
Hyperthyroidism
Leakage of fetal blood into maternal circulation
Leukemia (acute or chronic)
Myeloproliferative disorders
Sickle cell disease
Thalassemias

- β -Chain substitutions:
Hgb C (second most common variant in the United States, it has a higher prevalence among African Americans)
- Hgb C disease:
Hgb D (rare hemoglobinopathy that may also be found in combination with Hgb S or thalassemia)
- Splenomegaly without other significant clinical implications:
Hgb E (second most common hemoglobinopathy in the world, occurs with the highest frequency in Southeast Asians and African-Americans)
- Thalassemia-like condition:
Hgb S (most common variant in the United States, occurs with a frequency of about 8% among African Americans)
- Sickle cell trait or disease
- α -Chain substitutions:
Hgb H
- α -Thalassemias:
Bart's Hgb
- α -Thalassemias
- Hgb Bart's hydrops fetalis syndrome

Decreased in:

- Hgb A₂:
Erythroleukemia
- Hgb H disease
- Iron-deficiency anemia (untreated)
- Sideroblastic anemia

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- High altitude and dehydration may increase values.
- Iron deficiency may decrease Hgb A₂, C, and S.
- In patients less than 3 mo of age, false-negative results for Hgb S occur in coincidental polycythemia.
- Red blood cell transfusion within 4 mo of test can mask abnormal Hgb levels.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify hemoglobin variants and diagnose thalassemias.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop

bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may

be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, blood gases, complete blood count, complete blood count, hematocrit, complete blood count, hemoglobin, methemoglobin, osmotic fragility, complete blood count, RBC morphology, and sickle cell screen.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Hemosiderin

SYNONYM/ACRONYM: Hemosiderin stain, Pappenheimer body stain, iron stain.

SPECIMEN: Urine (5 mL) from a random first morning sample, collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Microscopic examination of Prussian blue–stained specimen) None seen.

DESCRIPTION: Hemosiderin stain is used to indicate the presence of iron storage granules called *hemosiderin* by microscopic examination of urine sediment. Granules of hemosiderin stain blue when potassium ferrocyanide is added to the sample. Hemosiderin is normally found in the liver, spleen, and bone marrow, but not in the urine. Under normal conditions, hemosiderin is absorbed by the renal tubules; however, in extensive hemolysis, renal tubule damage, or an iron metabolism disorder, hemosiderin

filters its way into the urine. The Prussian blue stain may also be used to identify siderocytes (iron-containing red blood cells [RBCs]) in peripheral blood. The presence of siderocytes in circulating RBCs is abnormal.

INDICATIONS:

- Assist in the diagnosis of hemochromatosis (tissue damage caused by iron toxicity)
- Detect excessive RBC hemolysis within the systemic circulation
- Evaluate renal tubule dysfunction

RESULT:**Increased in:**

Any condition that involves hemolysis will release hemoglobin from RBCs into circulation. Hemoglobin is converted to hemosiderin in the renal tubular epithelial cells.

- Burns
- Cold hemagglutinin disease
- Hemochromatosis
- Hemolytic transfusion reactions
- Mechanical trauma to RBCs
- Megaloblastic anemia
- Microangiopathic hemolytic anemia
- Paroxysmal nocturnal hemoglobinuria
- Pernicious anemia
- Sickle cell anemia
- Thalassemia major

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to indicate recent intravascular hemolysis and to assist in the diagnosis of unexplained anemia.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and genitourinary systems, especially a history of hemolytic anemia, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there should be no discomfort during the procedure.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a collection container.

General:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change

in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, biopsy kidney, BUN, complete blood count, CT renal, creatinine, creatinine clearance, D-dimer, ferritin, complete blood count, hematocrit, complete blood count, hemoglobin, iron/total iron-binding capacity, lead, aPTT, PT/INR, complete blood count, RBC count, complete blood count, RBC morphology, transferrin, and complete blood count, WBC count and differential.
- ▶ Refer to the Hematopoietic and Genitourinary System tables at the back of the book for related tests by body system.

Hepatitis A Antibody

SYNONYM/ACRONYM: HAV serology.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Enzyme immunoassay) Negative.

DESCRIPTION: The hepatitis A virus is classified as a picornavirus. Its primary mode of transmission is by the fecal-oral route under conditions of poor personal hygiene or inadequate sanitation. The incubation period is about 28 days, with a range of 15 to 50 days. Onset is usually abrupt, with the acute disease lasting about 1 wk. Therapy is supportive, and there is no development of chronic or carrier states. Assays for total (immunoglobulin G and immunoglobulin M [IgM]) hepatitis A antibody and IgM-specific

hepatitis A antibody assist in differentiating recent infection from prior exposure. If results from the IgM-specific or from both assays are positive, recent infection is suspected. If the IgM-specific test results are negative and the total antibody test results are positive, past infection is indicated. The clinically significant assay—IgM-specific antibody—is often the only test requested. Jaundice occurs in 70% to 80% of adult cases of HAV infection and in 70% of pediatric cases.

INDICATIONS:

- Screen individuals at high risk of exposure, such as those in long-term residential facilities or correctional facilities
- Screen individuals with suspected HAV infection

RESULT:**Positive findings in:**

- **Individuals with current hepatitis A infection**
- **Individuals with past hepatitis A infection**

CRITICAL VALUES: N/A**INTERFERING FACTORS:** N/A**H****NURSING IMPLICATIONS AND PROCEDURE****PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to test blood for the presence of antibodies that would indicate past or current hepatitis A infection.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Dietary recommendations may be indicated and will vary depending on the type and severity of the condition. Elimination of alcohol ingestion and a diet optimized for convalescence are commonly included in the treatment plan.
- ▶ **Social and cultural considerations:** Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Counsel the patient, as appropriate, regarding risk of transmission and proper prophylaxis. Immune globulin can be given before exposure (in the case of individuals who may be traveling to a location where the disease is endemic) or after exposure, during the incubation period. Prophylaxis is most effective when administered 2 wk after exposure.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Provide information regarding

vaccine-preventable diseases where indicated (e.g., encephalitis, Hepatitis A and B, human papillomavirus, influenza, measles, mumps, polio, rubella, smallpox, varicella, yellow fever). Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, ALP, AST, bilirubin, GGT, and HBV and HBC antigens and antibodies.
- ▶ Refer to the Hepatobiliary and Immune System tables at the back of the book for related tests by body system.

Hepatitis B Antigen and Antibody

H

SYNONYM/ACRONYM: HBeAg, HBeAb, HBcAb, HBsAb, HBsAg.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Enzyme immunoassay) Negative.

DESCRIPTION: The hepatitis B virus (HBV) is classified as a double-stranded DNA retrovirus of the Hepadnaviridae family. Its primary modes of transmission are parenteral, perinatal, and sexual contact. Serological profiles vary with different scenarios (i.e., asymptomatic infection, acute/resolved infection, coinfection, and chronic carrier state). The formation and detectability of markers is also dose dependent. The following description refers to HBV infection that becomes resolved. The incubation period is generally 6 to 16 wk. The hepatitis B surface antigen (HBsAg) is the first marker to appear after infection. It is detectable 8 to 12 wk after exposure and often precedes symptoms. At about the time liver enzymes fall back to normal

levels, the HBsAg titer has fallen to nondetectable levels. If the HBsAg remains detectable after 6 mo, the patient will likely become a chronic carrier who can transmit the virus. Hepatitis Be antigen (HBeAg) appears in the serum 10 to 12 wk after exposure. HBeAg can be found in the serum of patients with acute or chronic HBV infection and is a sign of active viral replication and infectivity. Levels of hepatitis Be antibody (HBeAb) appear about 14 wk after exposure, suggesting resolution of the infection and reduction of the patient's ability to transmit the disease. The more quickly HBeAg disappears, the shorter the acute phase of the infection. Immunoglobulin M-specific hepatitis B core antibody (HBcAb) appears 6 to

14 wk after exposure to HBsAg and continues to be detectable either until the infection is resolved or over the life span in patients who are in a chronic carrier state. In some cases, HBeAb may be the only detectable marker; hence, its lone appearance has sometimes been referred to as the *core window*. HBeAb is not an indicator of recovery or immunity; however, it does indicate current or previous infection. Hepatitis B surface antibody (HBsAb) appears 2 to 16 wk after HBsAg disappears. Appearance of HBsAb represents clinical recovery and immunity to the virus.

Onset of HBV infection is usually insidious. Most children and half of infected adults are asymptomatic. During the acute phase of infection, symptoms range from mild to severe. Chronicity decreases with age. HBsAg and HBeAb tests are used to screen donated blood before transfusion. HBsAg testing is often part of the routine prenatal screen. Vaccination of infants, children, and young adults is becoming a standard of care and in some cases a requirement.

INDICATIONS:

- Detect exposure to HBV
- Detect possible carrier status
- Pre- and postvaccination testing
- Routine prenatal testing
- Screen donated blood before transfusion
- Screen for individuals at high risk of exposure, such as hemodialysis patients, persons with multiple sex partners, persons with a history of other sexually transmitted diseases, IV drug abusers, infants born to infected mothers, individuals residing in long-term residential facilities or correctional facilities,

recipients of blood- or plasma-derived products, allied health care workers, and public service employees who come in contact with blood and blood products.

RESULT:

Positive findings in:

- **Patients currently infected with HBV**
- **Patients with a past HBV infection**

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Drugs that may decrease HBeAb and HBsAb include interferon.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to identify and confirm hepatitis B infection.
- ♦ Obtain a history of the patient's complaints, including a list of known allergies, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's hepatobiliary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a history of IV drug use, high-risk sexual activity, or occupational exposure.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Dietary recommendations may be indicated and will vary depending on the type and severity of the condition. Elimination of alcohol ingestion, and a diet optimized for convalescence are commonly included in the treatment plan. A high-calorie, high-protein, moderate-fat diet with a high fluid intake is often recommended for patients with hepatitis.
- ▶ **Cultural and social considerations:** Recognize anxiety related to test results, and be supportive of impaired activity related to lack of neuromuscular control, perceived loss of independence, and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- Educate the patient regarding access to counseling services. Counsel the patient, as appropriate, regarding risk of transmission and proper prophylaxis. Hepatitis B immune globulin (HBIG) vaccination should be given immediately after situations in which there is a potential for HBV exposure (e.g., accidental needle stick, perinatal period, sexual contact) for temporary, passive protection. Some studies have indicated that interferon alfa may be useful in the treatment of chronic hepatitis B.
- ▶ Counsel the patient and significant contacts, as appropriate, that HBIG immunization is available and has in fact become a requirement in many places as part of childhood immunization and employee health programs. Parents may choose to sign a waiver preventing their newborns from receiving the vaccine; they may choose not to vaccinate on the basis of philosophical, religious, or medical reasons. Vaccination regulations vary from state to state.
 - ▶ Inform the patient that positive findings must be reported to local health department officials, who will question him or her regarding sexual partners.
 - ▶ **Sensitivity to social and cultural considerations:** Offer support, as appropriate, to patients who may be the victims of rape or other forms of sexual assault, including children and elderly individuals. Educate the patient regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for a discussion during which the risks of sexually transmitted diseases are explained. It is also important to discuss the problems that the patient may experience (e.g., guilt, depression, anger).
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Provide information regarding vaccine-preventable diseases where indicated (e.g., encephalitis, Hepatitis A and B, human papillomavirus, influenza, measles, mumps, polio, rubella, smallpox, varicella, yellow fever). Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor

progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

▶ Related tests include ALT, ALP, antibodies, antimitochondrial, AST,

bilirubin, biopsy liver, *chlamydia* group antibody, cholangiography percutaneous transhepatic, culture anal, GGT, hepatitis C serology, HIV serology, liver and spleen scan, syphilis serology, and US liver.

▶ Refer to the Hepatobiliary and Immune System tables at the back of the book for related tests by body system.

Hepatitis C Antibody

SYNONYM/ACRONYM: HCV serology, hepatitis non-A/non-B.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Enzyme immunoassay, branched chain DNA [bDNA], polymerase chain reaction [PCR], recombinant immunoblot assay [RIBA]) Negative.

DESCRIPTION: The hepatitis C virus (HCV) causes the majority of blood-borne non-A, non-B hepatitis cases. Its primary modes of transmission are parenteral, perinatal, and sexual contact. The virus is thought to be a flavivirus and contains a single-stranded RNA core. The incubation period varies widely, from 2 to 52 wk. Onset is insidious, and the risk of chronic liver disease after infection is high. On average, antibodies to hepatitis C are detectable in approximately 45% of infected individuals within 6 wk of infection. The remaining 55% produce antibodies within the next 6 to 12 mo. Once infected with HCV, 50% of patients will become chronic carriers. Infected individuals and carriers have a high frequency of chronic liver diseases such as

cirrhosis and chronic active hepatitis, and they have a higher risk of developing hepatocellular cancer. The transmission of hepatitis C by blood transfusion has decreased dramatically since it became part of the routine screening panel for blood donors. The possibility of prenatal transmission exists, especially in the presence of HIV coinfection. Therefore, this test is often included in prenatal testing packages. Currently, nucleic acid amplification testing (NAT) is the only way to document the presence of ongoing infection. PCR and bDNA methods are recognized by the Centers of Disease Control (CDC) as appropriate supplemental testing for the confirmation of anti-HCV antibody.

INDICATIONS:

- Assist in the diagnosis of non-A, non-B viral hepatitis infection
- Monitor patients suspected of HCV infection but who have not yet produced antibody
- Routine prenatal testing
- Screen donated blood before transfusion

RESULT:**Positive findings in:**

- **Patients currently infected with HCV**
- **Patients with a past HCV infection**

Negative findings in: N/A

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

Drugs that may decrease hepatitis C antibody levels include interferon.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify and confirm hepatitis C infection.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a history of IV drug use, high-risk sexual activity, and occupational exposure.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen

collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Dietary recommendations may be indicated and will vary depending on the type and severity of the condition. Currently, for example, there are no specific medications that can be given to cure hepatitis; however, bed rest, elimination of alcohol ingestion, and a diet optimized for convalescence are commonly included in the treatment plan. A high-calorie, high-protein, moderate-fat diet with a high fluid intake is often recommended for patients with hepatitis.
- ▶ **Cultural and social considerations:** Recognize anxiety related to test results, and be supportive of impaired activity related to lack of neuromuscular

control, perceived loss of independence, and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Counsel the patient, as appropriate, regarding the risk of transmission and proper prophylaxis. Interferon alfa was approved in 1991 by the U.S. Food and Drug Administration for use as a therapeutic agent in the treatment of chronic HCV infection.

- ◆ Inform the patient that positive findings must be reported to local health department officials, who will question him or her regarding sexual partners.
- ◆ **Sensitivity to social and cultural considerations:** Offer support, as appropriate, to patients who may be the victims of rape or other forms of sexual assault, including children and elderly individuals. Educate the patient regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for a discussion during which the risks of sexually transmitted diseases are

explained. It is also important to discuss the problems that the patient may experience (e.g., guilt, depression, anger).

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ALT, ALP, antibodies, antimitochondrial, AST, bilirubin, biopsy liver, *chlamydia* group antibody, cholangiography percutaneous transhepatic, culture anal, GGT, hepatitis B serology, hepatobiliary scan, HIV serology, liver and spleen scan, syphilis serology, and US liver.
- ◆ Refer to the Hepatobiliary and Immune System tables at the back of the book for related tests by body system.

Hepatitis D Antibody

SYNONYM/ACRONYM: Delta hepatitis.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Enzyme immunoassay, EIA) Negative.

RESULT:

Positive findings in:

- **Individuals currently infected with HDV**

- **Individuals with a past HDV infection**

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Hepatobiliary Scan

SYNONYM/ACRONYM: Hepatobiliary imaging, biliary tract radionuclide scan, hepatobiliary scintigraphy, gallbladder scan, cholescintigraphy, HIDA (a technetium-99m disopropyl analogue) scan.

AREA OF APPLICATION: Bile ducts.

CONTRAST: IV contrast medium (aminodiacetic acid compounds), usually combined with technetium-99m.

DESCRIPTION: The hepatobiliary scan is a nuclear medicine study of the hepatobiliary excretion system. It is primarily used to determine the patency of the cystic and common bile ducts, but it can also be used to determine overall hepatic function, gallbladder function, presence of gallstones (indirectly), and sphincter of Oddi dysfunction. Technetium (Tc-99m) HIDA (tribromoethyl, an aminodiacetic acid) is injected IV and excreted into the bile duct system. A gamma camera detects the radiation emitted from the injected contrast medium, and a representative image of the duct system is obtained. The results are correlated with other diagnostic studies, such as IV cholangiography, computed tomography (CT) scan of the gallbladder, and ultrasonography. Gallbladder emptying or ejection fraction can be determined by administering a fatty meal or cholecystokinin to the patient. This procedure can be used before and after surgery to determine the extent of bile reflux.

INDICATIONS:

- Aid in the diagnosis of acute and chronic cholecystitis

- Aid in the diagnosis of suspected gallbladder disorders, such as inflammation, perforation, or calculi
- Assess enterogastric reflux
- Assess obstructive jaundice when done in combination with radiography or ultrasonography
- Determine common duct obstruction caused by tumors or choledocholithiasis
- Evaluate biliary enteric bypass patency
- Postoperatively evaluate gastric surgical procedures and abdominal trauma

RESULT:

Normal findings in:

- Normal shape, size, and function of the gallbladder with patent cystic and common bile ducts

Abnormal findings in:

- Cholecystitis (acalculous, acute, chronic)
- Common bile duct obstruction secondary to gallstones, tumor, or stricture
- Congenital biliary atresia or choledochal cyst
- Postoperative biliary leak, fistula, or obstruction
- Trauma-induced bile leak or cyst

CRITICAL VALUES: N/A

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Bilirubin levels greater than or equal to 30 mg/dL, depending on the radionuclide used, which may decrease hepatic uptake
- Other nuclear scans done within the previous 24 to 48 hr
- Fasting for more than 24 hr before the procedure, total parenteral nutrition, and alcoholism
- Ingestion of food or liquids within 2 to 4 hr before the scan

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Improper injection of the radionuclide that allows the tracer to seep deep into the muscle tissue can produce erroneous hot spots.
- Inaccurate timing of imaging after the radionuclide injection can affect the results.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from

frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure detects inflammation or obstruction of the gallbladder or bile duct system.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ♦ Obtain a history of results of the patient's hepatobiliary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Address concerns about pain and explain to the patient that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in a nuclear medicine department by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ Inform the patient that the HCP will place him or her in a supine position on a flat table.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to restrict food and fluids for 4 to 6 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluids, and medication restrictions for 4 to 6 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to lie still during the procedure because movement produces unclear images.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in a supine position on a flat table with foam wedges to help maintain position and immobilization.
- ▶ IV radionuclide is administered, and the upper right quadrant of the abdomen is scanned immediately, with images then taken every 5 min for the

- first 30 min and every 10 min for the next 30 min. Delayed views are taken in 2, 4, and 24 hr if the gallbladder cannot be visualized, in order to differentiate acute from chronic cholecystitis or to detect the degree of obstruction.
- ▶ IV morphine may be administered during the study to initiate spasms of the sphincter of Oddi, forcing the radionuclide into the gallbladder, if the organ is not visualized within 1 hr of injection of the radionuclide. Imaging is then done 20 to 50 min later to determine delayed visualization or nonvisualization of the gallbladder.
- ▶ If gallbladder function or bile reflux is being assessed, the patient will be given a fatty meal or cholecystokinin 60 min after the injection.
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity as directed by the HCP.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to immediately flush the toilet and to meticulously

wash hands with soap and water after each voiding for 24 hr after the procedure.

- ◆ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash ungloved hands after the gloves are removed.
- ◆ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.

Answer any questions or address any concerns voiced by the patient or family.

- ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include amylase, bilirubin, CT abdomen, lipase, liver and spleen scan, MRI abdomen, radiofrequency ablation liver, and US liver and bile ducts.
- ◆ Refer to the Hepatobiliary System table at the back of the book for related tests by body system.

H

Hexosaminidase A and B

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (3 mL) collected in a red-top tube. After the specimen is collected, it must be brought *immediately* to the laboratory. Once in the laboratory, the specimen must be allowed to clot for 1 to 1.5 hr in the refrigerator. The serum should then be removed and frozen immediately.

REFERENCE VALUE: (Method: Fluorometry)

Total Hexosaminidase	Conventional Units	SI Units (Conventional Units × 0.0167)
Noncarrier	589–955 nmol/hr/mL	9.83–15.95 units/L
Heterozygote	465–675 nmol/hr/mL	3.30–5.39 units/L
Tay-Sachs homozygote	Greater than 1027 nmol/hr/mL	Greater than 17.15 units/L

Hexosaminidase A	Conventional Units	SI Units (Conventional Units × 0.0167)
Noncarrier	456–592 nmol/hr/mL	7.2–9.88 units/L
Heterozygote	197–323 nmol/hr/mL	3.3–5.39 units/L
Tay-Sachs homozygote	0 nmol/hr/mL	0 units/L

Hexosaminidase B	Conventional Units	SI Units (Conventional Units \times 0.0167)
Noncarrier	12–32 nmol/hr/mL	0.2–0.54 units/L
Heterozygote	21–81 nmol/hr/mL	0.35–1.35 units/L
Tay-Sachs homozygote	Greater than 305 nmol/hr/mL	Greater than 5.09 units/L

DESCRIPTION: Hexosaminidase is a lysosomal enzyme. There are three predominant isoenzymes: hexosaminidase A, B, and S. Deficiency results in the accumulation of complex sphingolipids and gangliosides in the brain. There are more than 70 lysosomal enzyme disorders. Testing for hexosaminidase A is done to determine the presence of Tay-Sachs disease, a genetic autosomal recessive condition characterized by early and progressive retardation of physical and mental development. This enzyme deficiency is most common among Ashkenazi Jews. Patients who are homozygous for this trait have no hexosaminidase A and have greatly elevated levels of hexosaminidase B; signs and symptoms include red spot in the retina, blindness, and muscular weakness. Tay-Sachs disease results in early death, usually by age 3 or 4.

INDICATIONS:

- Assist in the diagnosis of Tay-Sachs disease
- Identify carriers with hexosaminidase deficiency

RESULT:

Increased in:

Alterations in lysosomal enzymes metabolism are associated with various conditions.

- Total:
Gastric cancer

Hepatic disease
Myeloma
Myocardial infarction
Pregnancy
Symptomatic porphyria
Vascular complications of diabetes

- Hexosaminidase A:
Diabetes
Pregnancy
- Hexosaminidase B:
Tay-Sachs disease

Decreased in:

- Total
Sandhoff's disease (*Inherited disorder of enzyme metabolism lacking both essential enzymes for metabolizing gangliosides*)
- Hexosaminidase A:
Tay-Sachs disease (*Inherited disorder of enzyme metabolism lacking only the hexosaminidase A enzyme for metabolizing gangliosides*)
- Hexosaminidase B:
Sandhoff's disease

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Drugs that may increase hexosaminidase levels include ethanol, isoniazid, oral contraceptives, and rifampin.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to identify carrier status for Tay-Sachs disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ **Immediately** transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider

(HCP), who will discuss the results with the patient.

- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Encourage the family to seek genetic counseling if results are abnormal. It is also important to discuss feelings the mother and father may experience (e.g., guilt, depression, anger) if abnormalities are detected. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the National Tay Sachs and Allied Diseases Association (www.ntsad.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, amniotic fluid analysis, bilirubin, biopsy chorionic villus, biopsy liver, blood pool imaging, cancer antigens, capsule endoscopy, ceruloplasmin, chromosome analysis, CT cardiac scoring, CK and isoenzymes, GGT, gastric acid stimulation, gastrin stimulation, GH, *Helicobacter pylori*, Holter monitor, liver and spleen scan, myocardial infarction scan, myocardial perfusion scan, myoglobin, PET heart, protein total and fractions, radiography bone, troponin, upper GI series, and complete blood count, WBC count and differential.
- ▶ Refer to the Reproductive System table at the back of the book for related tests by body system.

Holter Monitor

SYNONYM/ACRONYM: Holter electrocardiography, ambulatory monitoring, ambulatory electrocardiography, event recorder.

AREA OF APPLICATION: Heart.

CONTRAST: None.

DESCRIPTION: The Holter monitor records electrical cardiac activity on a continuous basis for 24 to 48 hr. This noninvasive study includes the use of a portable device worn around the waist or over the shoulder that records cardiac electrical impulses on a magnetic tape. The recorder has a clock that allows accurate time markings on the tape. The patient is asked to keep a log or diary of daily activities and to record any occurrence of cardiac symptoms. When the client pushes a button indicating that symptoms (e.g., pain, palpitations, dyspnea, syncope) have occurred, an event marker is placed on the tape for later comparison with the cardiac activity recordings and the daily activity log. Some recorders allow the data to be transferred to the physician's office by telephone, where the tape is interpreted by a computer to detect any significantly abnormal variations in the recorded waveform patterns.

INDICATIONS:

- Detect arrhythmias that occur during normal daily activities, and correlate them with symptoms experienced by the patient
- Evaluate activity intolerance related to oxygen supply and demand imbalance
- Evaluate chest pain, dizziness, syncope, and palpitations
- Evaluate the effectiveness of antiarrhythmic medications for dosage adjustment, if needed
- Evaluate pacemaker function
- Monitor for ischemia and arrhythmias after myocardial infarction or cardiac surgery before changing rehabilitation and other therapy regimens

RESULT:

Normal findings in:

- Normal sinus rhythm

Abnormal findings in:

- Arrhythmias such as premature ventricular contractions, bradyarrhythmias, tachyarrhythmias, conduction defects, and bradycardia
- Cardiomyopathy
- Hypoxic or ischemic changes
- Mitral valve abnormality
- Palpitations

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- Improper placement of the electrodes or movement of the electrodes
- Failure of the patient to maintain a daily log of symptoms or to push the button to produce a mark on the strip when experiencing a symptom

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure evaluates the heart's response to normal activity or to a medication regimen.
- ▶ Obtain a history of the patient's complaints or symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums. Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that no electricity is delivered to the body during this procedure and no discomfort is experienced during monitoring. Inform the patient that the electrocardiography (ECG) recorder is worn for 24 to 48 hr, at which time the patient is to return to the laboratory with an activity log to have the monitor and strip removed for interpretation.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to wear loose-fitting clothing over the electrodes and not to disturb or disconnect the electrodes or wires.
- ▶ Advise the patient to avoid contact with electrical devices that can affect the strip tracings (e.g., shavers, toothbrush, massager, blanket) and to avoid showers and tub bathing.
- ▶ Instruct the patient to perform normal activities, such as walking, sleeping, climbing stairs, sexual activity, bowel or urinary elimination, cigarette smoking, emotional upsets, and medications, and to record them in an activity log.
- ▶ Instruct the patient regarding recording and pressing the button upon experiencing pain or discomfort.

- ▶ Advise the patient to report a light signal on the monitor, which indicates equipment malfunction or that an electrode has come off.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in a supine position.
- ▶ Expose the chest. Shave excessive hair at the skin sites; cleanse thoroughly with alcohol and rub until red in color.
- ▶ Apply electropaste to the skin sites to provide conduction between the skin and electrodes, or apply prelubricated disk electrodes that are disposable.
- ▶ Apply two electrodes (negative electrodes) on the manubrium, one in the V₁ position (fourth intercostal space at the border of the right sternum), and one at the V₅ position (level of the fifth intercostal space at the midclavicular line, horizontally and at the left axillary line). A ground electrode is also placed and secured to the skin of the chest or abdomen.
- ▶ After checking to ensure that the electrodes are secure, attach the electrode cable to the monitor and the lead wires to the electrodes.
- ▶ Check the monitor for paper supply and battery, insert the tape, and turn on the recorder. Tape all wires to the chest, and place the belt or shoulder strap in the proper position.

POST-TEST:

- ▶ After the patient has worn the monitor for the required 24 to 48 hr, gently remove the tape and other items securing the electrodes to him or her.
- ▶ The activity log and tape recording are compared for changes during the monitoring period.
- ▶ A report of the examination will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Advise the patient to immediately report symptoms such as fast heart rate or difficulty breathing.

- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed

to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, blood pool imaging, calcium, chest x-ray, echocardiography, echocardiography transesophageal, electrocardiogram, exercise stress test, magnesium, myocardial perfusion heart scan, PET heart, and potassium.
- ▶ Refer to the Cardiovascular System table at the back of the book for related tests by body system.

Homocysteine and Methylmalonic Acid

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (4 mL) collected in a red- or tiger-top tube if methylmalonic acid and homocysteine are to be measured together. Alternatively, plasma collected in a lavender-top (EDTA) tube may be acceptable for the homocysteine measurement. The laboratory should be consulted before specimen collection because specimen type may be method dependent. Care must be taken to use the same type of collection container if serial measurements are to be taken.

REFERENCE VALUE: (Method: Chromatography) Homocysteine: 4.6–11.2 micromol/L; methylmalonic acid: 70–270 nmol/L.

DESCRIPTION: Homocysteine is an amino acid formed from methionine. Normally homocysteine is rapidly remethylated in a biochemical pathway that requires vitamin B₁₂ and folate, preventing the buildup of homocysteine in the blood. Excess levels damage the endothelial lining of blood vessels; change coagulation factor levels, increasing the risk of blood clot formation; prevent smaller arteries from dilating, increasing

the risk of plaque formation; cause platelet aggregation; and cause smooth muscle cells lining the arterial wall to multiply, promoting atherosclerosis.

Approximately one-third of patients with hyperhomocystinuria have normal fasting levels. Patients with a heterozygous biochemical enzyme defect in cystathionine B synthase or with a nutritional deficiency in vitamin B₆ can be identified through the administration of a

methionine challenge or loading test. Specimens are collected while fasting and 2 hr later. An increase in homocysteine after 2 hr is indicative of hyperhomocystinuria. In patients with vitamin B₁₂ deficiency, elevated levels of methylmalonic acid and homocysteine develop fairly early in the course of the disease. Unlike vitamin B₁₂ levels, homocysteine levels will remain elevated for at least 24 hr after the start of vitamin therapy. This may be useful if vitamin therapy is inadvertently begun before specimen collection. Patients with folate deficiency, for the most part, will only develop elevated homocysteine levels. Hyperhomocysteinemia due to folate deficiency in pregnant women is believed to increase the risk of neural tube defects. Elevated levels of homocysteine are thought to chemically damage the exposed neural tissue of the developing fetus.

INDICATIONS:

- Evaluate inherited enzyme deficiencies that result in homocystinuria
- Evaluate the risk for cardiovascular disease
- Evaluate the risk for venous thrombosis

RESULT:

Increased in:

- Chronic renal failure
(**Pathophysiology is unclear**)
- Coronary artery disease (CAD)
(**There is a relationship but the pathophysiology is not clear**)
- Folic acid deficiency (**Folate is required for completion of biochemical reactions involved in homocysteine metabolism**)
- Homocystinuria (**Inherited disorder of methionine metabolism**)

that results in accumulation of homocysteine)

- Vitamin B₁₂ deficiency (**Vitamin B₁₂ is required for completion of biochemical reactions involved in homocysteine metabolism**)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase plasma homocysteine levels include anti-convulsants, cycloserine, hydralazine, isoniazid, methotrexate, penicillamine, phenelzine, and theophylline.
- Specimens should be kept at a refrigerated temperature and delivered immediately to the laboratory for processing.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to screen for risk of cardiovascular disease and stroke.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's cardiovascular and hematopoietic systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological

support before, during, and after the procedure.

- There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen for combined methylmalonic acid and homocysteine studies in two 5-mL red- or tiger-top tubes. If only homocysteine is to be measured, a 5-mL lavender-top tube is acceptable.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Nutritional considerations:** Increased homocysteine levels may be associated with atherosclerosis and CAD. Nutritional therapy is recommended for individuals identified to be at high risk for developing CAD. If overweight, these patients should be encouraged to achieve a normal weight. The American Heart Association has Step 1 and Step 2 diets that may be helpful in achieving a goal of lowering total cholesterol and triglyceride levels. The Step 1 diet emphasizes a reduction in foods high in saturated fats and cholesterol. Red meats, eggs, and dairy products are the major sources of saturated fats and cholesterol. If triglycerides are also elevated, patients should be advised to

eliminate or reduce alcohol and simple carbohydrates from their diet. The Step 2 diet recommends stricter reductions.

- Nutritional considerations:** Diets rich in fruits, grains, and cereals, in addition to a multivitamin containing B₁₂ and folate, may be recommended for patients with elevated homocysteine levels. Processed and refined foods should be kept to a minimum.
- Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Heart Association (www.americanheart.org).
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, ANP, blood gases, BMD, BNP, BUN, calcitonin, calcium, cholesterol (total, HDL, and LDL), complete blood count, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology, complete blood count, WBC count and differential, CRP, CK and isoenzymes, creatinine, folate, glucose, glycated hemoglobin, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, myoglobin, osteocalcin, PTH, pericardial fluid analysis, potassium, pre-albumin, renogram, triglycerides, troponin, US kidney, UA, and vitamin B₁₂.
- Refer to the Cardiovascular and Hematopoietic System tables at the back of the book for related tests by body system.

Homovanillic Acid

SYNONYM/ACRONYM: HVA.

SPECIMEN: Urine (10 mL) from a timed specimen collected in a clean plastic collection container with 6N HCl as a preservative.

REFERENCE VALUE: (Method: Chromatography)

Age	Conventional Units	SI Units
<i>Homovanillic acid (Conventional Units × 5.49)</i>		
3–6 yr	1.4–4.3 mg/24 hr	8–24 micromol/24 hr
7–10 yr	2.1–4.7 mg/24 hr	12–26 micromol/24 hr
11–16 yr	2.4–8.7 mg/24 hr	13–48 micromol/24 hr
Adult	1.4–8.8 mg/24 hr	8–48 micromol/24 hr
<i>Vanillylmandelic Acid (Conventional Units × 5.05)</i>		
3–6 yr	1.0–2.6 mg/24 hr	5–13 micromol/24 hr
7–10 yr	2.0–3.2 mg/24 hr	10–16 micromol/24 hr
11–16 yr	2.3–5.2 mg/24 hr	12–26 micromol/24 hr
Adult	1.4–6.5 mg/24 hr	7–33 micromol/24 hr

DESCRIPTION: Homovanillic acid (HVA) is the main terminal metabolite of dopamine. Vanillylmandelic acid is a major metabolite of epinephrine and norepinephrine. Both of these tests should be evaluated together for the diagnosis of neuroblastoma. Excretion may be intermittent; therefore, a 24-hour specimen is preferred. Creatinine is usually measured simultaneously to ensure adequate collection and to calculate an excretion ratio of metabolite to creatinine.

INDICATIONS:

- Assist in the diagnosis of pheochromocytoma, neuroblastoma, and ganglioblastoma
- Monitor the course of therapy

RESULT:

Increased in:

HVA is excreted in excessive amounts in the following conditions:

- Ganglioblastoma
- Neuroblastoma
- Pheochromocytoma
- Riley-Day syndrome

Decreased in:

- Schizotypal personality disorders

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase HVA levels include acetylsalicylic acid, disulfiram, levodopa, pyridoxine, and reserpine.
- Drugs that may decrease HVA levels include moclobemide.
- All urine voided for the timed collection period must be included

in the collection or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to diagnose neuroblastoma, pheochromocytoma, and ganglioblastoma, and to monitor therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.

- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ If possible, and with medical direction, patients should withhold acetylsalicylic acid, disulfiram, pyridoxine, and reserpine for 2 days before specimen collection. Levodopa should be withheld for 2 wk before specimen collection.
- ▶ There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions; assure that specified medications, with medical direction, have been restricted for at least 2 days prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 a.m. and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the

beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.

- ◆ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger refrigerated container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ◆ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- ◆ Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that can affect test results.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider

(HCP), who will discuss the results with the patient.

- ◆ Instruct the patient to resume usual medications, as directed by the HCP.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include angiography adrenal, CEA, catecholamines, CT renal, metanephrines, renin, and VMA.
- ◆ Refer to the Endocrine System table at the back of the book for related tests by body system.

Human Chorionic Gonadotropin

SYNONYM/ACRONYM: Chorionic gonadotropin, pregnancy test, HCG, hCG, α -HCG, β -subunit HCG.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Immunoassay)

	Conventional Units	SI Units (Conventional Units × 1)
Males and nonpregnant females	Less than 5 milli international units/mL	Less than 5 international units/L
Pregnant females by week of gestation:		
<i>Less than 1 wk</i>	5–50 milli international units/mL	5–50 international units/L
<i>2 wk</i>	50–500 milli international units/mL	50–500 international units/L
<i>3 wk</i>	100–10,000 milli international units/mL	100–10,000 international units/L
<i>4 wk</i>	1,000–30,000 milli international units/mL	1,000–30,000 international units/L
<i>5 wk</i>	3,500–115,000 milli international units/mL	3,500–115,000 international units/L
<i>6–8 wk</i>	12,000–270,000 milli international units/mL	12,000–270,000 international units/L
<i>12 wk</i>	15,000–220,000 milli international units/mL	15,000–220,000 international units/L

DESCRIPTION: Human chorionic gonadotropin (HCG) is a hormone secreted by the placenta beginning 8 to 10 days after conception, which coincides with implantation of the fertilized ovum. It stimulates secretion of progesterone by the corpus luteum. HCG levels peak at 8 to 12 wk of gestation and then fall to less than 10% of first trimester levels by the end of pregnancy. By postpartum wk 2, levels are undetectable. HCG levels increase at a slower rate in ectopic pregnancy and spontaneous abortion than in normal pregnancy; a low rate of change between serial specimens is predictive of a nonviable fetus. As assays improve in sensitivity over time, ectopic pregnancies are increasingly being identified before rupture. HCG is used along with α -fetoprotein, dimeric inhibin-A, and estriol in prenatal screening for neural tube defects.

These prenatal measurements are also known as *triple* or *quad markers*, depending on which tests are included. Serial measurements are needed for an accurate estimate of gestational stage and determination of fetal viability. Triple- and quad-marker testing has also been used to screen for trisomy 21 (Down syndrome). (To compare HCG to other tests in the triple- and quad-marker screening procedure, see monograph titled “ α_1 -Fetoprotein.”) HCG is also produced by some germ cell tumors. Most assays measure both the intact and free β -HCG subunit, but if HCG is to be used as a tumor marker, the assay must be capable of detecting both intact and free β -HCG.

INDICATIONS:

- Assist in the diagnosis of suspected HCG-producing tumors,

such as choriocarcinoma, germ cell tumors of the ovary and testes, or hydatidiform moles

- Confirm pregnancy, assist in the diagnosis of suspected ectopic pregnancy, or determine threatened or incomplete abortion
- Determine adequacy of hormonal levels to maintain pregnancy
- Monitor effects of surgery or chemotherapy
- Monitor ovulation induction treatment
- Prenatally detect neural tube defects and trisomy 21 (Down syndrome)

RESULT:

Increased in:

- Choriocarcinoma (**HCG-producing tumor**)
- Ectopic HCG-producing tumors (stomach, lung, colon, pancreas, liver, breast)
- Erythroblastosis fetalis (**Hemolytic anemia as a result of fetal sensitization by incompatible maternal blood group antigens such as Rb, Kell, Kidd, Duffy is associated with increased HCG levels**)
- Germ cell tumors (ovary and testes) (**HCG-producing tumors**)
- Hydatidiform mole (**HCG-secreting mole**)
- Islet cell tumors (**HCG-producing tumors**)
- Multiple gestation pregnancy (**Related to increased levels produced by the presence of multiple fetuses**)
- Pregnancy (**Related to increased production by placenta**)

Decreased in:

Any condition associated with diminished viability of the placenta will reflect decreased levels.

- Ectopic pregnancy (**HCG levels increase slower than in viable intrauterine pregnancies, plateau, and then decrease prior to rupture**)

- Incomplete abortion
- Intrauterine fetal demise
- Spontaneous abortion
- Threatened abortion

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may decrease HCG levels include epostane and mifepristone.
- Results may vary widely depending on the sensitivity and specificity of the assay. Performance of the test too early in pregnancy may cause false-negative results. HCG is composed of an α and a β subunit. The structure of the α subunit is essentially identical to the β subunit of follicle-stimulating hormone, luteinizing hormone, and thyroid-stimulating hormone. The structure of the β subunit differentiates HCG from the other hormones. False-positive results can therefore be obtained if the HCG assay does not detect β subunit.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient, as appropriate, that the test is used to verify pregnancy, screen for neural tube defects, or detect HCG-secreting tumors.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine, immune, and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Social and cultural considerations:** Recognize anxiety related to abnormal test results, and encourage the family to seek counseling if concerned with pregnancy termination or to seek genetic counseling if a chromosomal abnormality is determined. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Decisions regarding elective abortion should take place in the presence of both parents. Provide a nonjudgmental, nonthreatening atmosphere for discussing the risks

and difficulties of delivering and raising a developmentally challenged infant, as well as exploring other options (termination of pregnancy or adoption). It is also important to discuss feelings the mother and father may experience (e.g., guilt, depression, anger) if fetal abnormalities are detected.

- ▶ **Social and cultural considerations:** Offer support, as appropriate, to patients who may be the victims of rape or sexual assault. Educate the patient regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for a discussion during which risks of sexually transmitted diseases are explained. It is also important to discuss problems the victim of sexual assault may experience (e.g., guilt, depression, anger) if there is possibility of pregnancy related to the assault.
- ▶ **Social and cultural considerations:** In patients with carcinoma, recognize anxiety related to test results and offer support. Provide teaching and information regarding the clinical implications of abnormal test results, as appropriate. Educate the patient regarding access to counseling services, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor the patient's condition and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related laboratory tests include biopsy chorionic villus, *Chlamydia* group antibody, chromosome analysis, CMV, estradiol, fetal fibronectin, α_1 -fetoprotein, complete blood count, hematocrit, complete blood count, hemoglobin, progesterone, rubella antibody, rubeola antibody, syphilis serology, toxoplasma antibody, US biophysical profile obstetric, and complete blood count, WBC count and differential.
- ▶ Refer to the Endocrine, Immune, and Reproductive System tables at the back of the book for related tests by body system.

Human Immunodeficiency Virus Type 1 and Type 2 Antibodies

SYNONYM/ACRONYM: HIV-1/HIV-2.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Enzyme immunoassay) Negative.

DESCRIPTION: Human immunodeficiency virus (HIV) is the etiologic agent of AIDS and is transmitted through bodily secretions, especially by blood or sexual contact. The virus preferentially binds to the T4 helper lymphocytes and replicates within the cells. Current assays detect several viral proteins. Positive results should be confirmed by Western blot assay. This test is routinely recommended as part of a prenatal work-up and is required for evaluating donated blood units before release for transfusion. The Centers for Disease Control and Prevention (CDC) has structured its recommendations to increase identification of HIV-infected patients as early as possible; early identification increases treatment options, increases frequency of successful treatment, and can decrease further spread of disease. Current recommendations presented in Advancing HIV Prevention: New Strategies for a Changing Epidemic 2003–2005 (www.cdc.gov):

- Include HIV testing in routine medical care; screening of all patients between the ages of 13 and 64 years of age as part of routine medical care.
- Implement new models to diagnose HIV infections outside

medical settings; availability of rapid waived testing kits like OraQuick®.

- Prevent new infections by working with persons diagnosed with HIV and their partners; adapt a voluntary opt-out approach that includes elimination of pretest counseling and written consent requirements.
- Further decrease prenatal transmission of HIV by incorporating HIV testing as a routine part of prenatal medical care.

INDICATIONS:

- Evaluate donated blood units before transfusion
- Perform as part of prenatal screening
- Screen organ transplant donors
- Test individuals who have documented and significant exposure to other infected individuals
- Test exposed high-risk individuals for detection of antibody (e.g., persons with multiple sex partners, persons with a history of other sexually transmitted diseases, IV drug users, infants born to infected mothers, allied health care workers, public service employees who have contact with blood and blood products)

RESULT:**Positive findings in:
HIV-1 or HIV-2 infection****CRITICAL VALUES:** N/A**INTERFERING FACTORS:**

- Drugs that may decrease HIV antibody levels include didanosine, dideoxycytidine, zalcitabine, and zidovudine.
- Nonreactive HIV test results occur during the acute stage of the disease, when the virus is present but antibodies have not sufficiently developed to be detected. It may take up to 6 mo for the test to become positive. During this stage, the test for HIV antigen may not confirm an HIV infection.
- Test kits for HIV are very sensitive. As a result, nonspecific reactions may occur, leading to a false-positive result.

**NURSING IMPLICATIONS
AND PROCEDURE****PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to test blood for the presence of antibodies to HIV.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and reproductive systems, a history of high-risk behaviors, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain

and explain that there may be some discomfort during the venipuncture.

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Warn the patient that false-positive results occur and that the absence of antibody does not guarantee absence of infection, because the virus may be latent or may not have produced detectable antibody at the time of testing.
- ▶ **Social and cultural considerations:** Recognize anxiety related to test results, and be supportive of impaired activity related to weakness, perceived loss of independence, and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

Educate the patient regarding access to counseling services. Provide contact information, if desired, for AIDS information provided by the National Institutes of Health (www.aidsinfo.nih.gov).

▶ **Social and cultural considerations:**

Counsel the patient, as appropriate, regarding risk of transmission and proper prophylaxis, and reinforce the importance of strict adherence to the treatment regimen, including consultation with a pharmacist.

▶ **Social and cultural considerations:** Inform patient that positive findings must be reported to local health department officials, who will question him or her regarding sexual partners.

▶ **Social and cultural considerations:** Offer support, as appropriate, to patients who may be the victims of rape or sexual assault. Educate the patient regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for a discussion during which risks of sexually transmitted diseases are explained. It is also important to discuss problems the patient may experience (e.g., guilt, depression, anger).

▶ Inform the patient that retesting may be necessary.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, bronchoscopy, CD4/CD8 enumeration, *Chlamydia* group antibody, complete blood count, culture and smear mycobacteria, culture viral, cytology sputum, CMV, culture skin, gallium scan, HBV antibody and antigen, HCV antibody, human T-cell lymphotropic virus types I and II, laparoscopy abdominal, LAP, lymphangiogram, MRI musculoskeletal, mediastinoscopy, β_2 -microglobulin, complete blood count, platelet count, syphilis serology, and complete blood count, WBC count and differential.
- ▶ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Human Leukocyte Antigen B27

SYNONYM/ACRONYM: HLA-B27.

SPECIMEN: Whole blood (5 mL) collected in green-top (heparin) or yellow-top (acid-citrate-dextrose [ACD]) tube.

REFERENCE VALUE: (Method: Flow cytometry) Negative (indicating absence of the antigen).

DESCRIPTION: The human leukocyte antigens (HLAs) are gene products of the major histocompatibility complex, derived from their respective loci on the short

arm of chromosome 6. There are more than 27 identified HLAs. HLA-B27 is an allele (one of two or more genes for an inheritable trait that occupy the

same location on each chromosome, paternal and maternal) of the HLA-B locus. The antigens are present on the surface of nucleated tissue cells as well as on white blood cells. HLA testing is used in determining histocompatibility for organ and tissue transplantation. Another application for HLA testing is in paternity investigations. The presence of HLA-B27 is associated with several specific conditions, but HLA-B27 should not be used as a screening test for these conditions.

INDICATIONS:

Assist in diagnosing ankylosing spondylitis and Reiter's syndrome

RESULT:

Positive findings in:

- Ankylosing spondylitis
- Juvenile rheumatoid arthritis
- Psoriatic arthritis
- Reiter's syndrome

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- The specimen should be stored at room temperature and should be received by the laboratory performing the assay within 24 hr of collection. It is highly recommended that the laboratory be contacted before specimen collection to avoid specimen rejection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to evaluate ankylosing spondylitis and other disorders associated with HLA-B27.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider

(HCP), who will discuss the results with the patient.

- ◆ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. These diseases can be moderately to severely debilitating, resulting in significant lifestyle changes. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that false-positive test results occur and that retesting

may be required. Answer any questions or address any concerns voiced by the patient or family.

- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ANA, complete blood count, CT spine, ESR, MRI musculoskeletal, radiography bone, and RF.
- ◆ Refer to the Immune and Musculoskeletal System tables at the back of the book for related tests by body system.

H

Human T-Lymphotropic Virus Type I and Type II Antibodies

SYNONYM/ACRONYM: HTLV-I/HTLV-II.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Enzyme immunoassay) Negative.

DESCRIPTION: Human T-lymphotropic virus type I (HTLV-I) and type II (HTLV-II) are two closely related retroviruses known to remain latent for extended periods before becoming reactive. The viruses are transmitted by sexual contact, contact with blood, placental transfer from mother to fetus, or ingestion of breast milk. As with HIV-1 and HIV-2, HTLV targets the T4 lymphocytes. The disease is uncommon in the United States, but retrospective

studies conducted by the American Red Cross demonstrated that a small percentage of transfusion recipients became infected by HTLV-positive blood. The results of this study led to a requirement that all donated blood units be tested for HTLV-I/HTLV-II before release for transfusion.

INDICATIONS:

- Distinguish HTLV-I/HTLV-II infection from spastic myelopathy

- Establish HTLV-I as the causative agent in adult lymphoblastic (T-cell) leukemia
- Evaluate donated blood units before transfusion
- Evaluate HTLV-II as a contributing cause of chronic neuromuscular disease

RESULT:**Positive findings in:**

- **HTLV-I/ HTLV-II infection**

CRITICAL VALUES: N/A**INTERFERING FACTORS:** N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to test blood for the presence of antibodies that would indicate past or current HTLV infection.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune system, a history of high-risk behaviors, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Warn the patient that false-positive results occur and that the absence of antibody does not guarantee absence of infection, because the virus may be latent or not have produced detectable antibody at the time of testing.
- ▶ **Social and cultural considerations:** Recognize anxiety related to test results, and be supportive of impaired activity related to weakness, perceived loss of independence, and fear of shortened life expectancy. Discuss the implications of positive test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ **Social and cultural considerations:** Counsel the patient, as appropriate, regarding risk of transmission and proper prophylaxis, and reinforce the importance of strict adherence to the

treatment regimen, including consultation with a pharmacist.

- ▶ Inform the patient that the presence of HTLV-I/HTLV-II antibodies precludes blood donation, but it does not mean that leukemia or a neurological disorder is present or will develop.
- ▶ Inform the patient that subsequent retesting may be necessary.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count, hepatitis B, C, and D antigens and antibodies, and HIV-1/HIV-2.
- ▶ Refer to the Immune System table at the back of the book for related tests by body system.

H 5-Hydroxyindoleacetic Acid

SYNONYM/ACRONYM: 5-HIAA.

SPECIMEN: Urine (10 mL) from a timed specimen collected in a clean plastic collection container with boric acid as a preservative.

REFERENCE VALUE: (Method: High-pressure liquid chromatography)

Conventional Units	SI Units (Conventional Units × 5.23)
2–7 mg/24 hr	10.5–36.6 micromol/24 hr

DESCRIPTION: Because 5-hydroxyindoleacetic acid (5-HIAA) is a metabolite of serotonin, 5-HIAA levels reflect plasma serotonin concentrations. 5-HIAA is excreted in the urine. Increased urinary excretion occurs in the presence of carcinoid tumors. This test, which replaces serotonin measurement, is most accurate when obtained from a 24-hr urine specimen.

INDICATIONS:

Detect early, small, or intermittently secreting carcinoid tumors

RESULT:

Increased in:

Serotonin is produced by the enterochromaffin cells of the small intestine and secreted ectopically by tumor cells. It is converted to 5-HIAA in the liver and excreted in the urine. Increased values are associated with malabsorption conditions but the relationship is not clear.

- Celiac and tropical sprue
- Cystic fibrosis
- Foregut and midgut carcinoid tumors
- Oat cell carcinoma of the bronchus

- Ovarian carcinoid tumors
- Whipple's disease

Decreased in:

The documented relationship between decreased levels of serotonin, defective amino acid metabolism, and mental illness is not clear.

- Depressive illnesses
- Hartnup disease
- Mastocytosis
- Phenylketonuria
- Renal disease (**Related to decreased renal excretion**)
- Small intestine resection (**Related to a decrease in enterochromaffin-producing cells**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase 5-HIAA levels include acetaminophen, cisplatin, ephedrine, fluorouracil, cough syrups containing glyceryl guaiacolate, melphalan, mephenesin, methocarbamol, naproxen, phenacetin, pindolol, and rauwolfia alkaloids.
- Drugs that may decrease 5-HIAA levels include corticotropin, ethanol, imipramine, isoniazid, levodopa, methamphetamine, methyl dopa, monoamine oxidase inhibitors, and phenothiazines.
- Foods containing serotonin, such as avocados, bananas, chocolate, eggplant, pineapples, plantains, red plums, tomatoes, and walnuts, can falsely elevate levels if ingested within 4 days of specimen collection.
- Severe gastrointestinal disturbance or diarrhea can interfere with test results.
- Failure to collect all the urine and store the specimen properly during the 24-hr test period invalidates the results.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to diagnose carcinoid tumors.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine, gastrointestinal, and immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain to the patient that there should be no discomfort during the procedure.
- ▶ Inform the patient that all urine collected over a 24-hr period must be saved; if a preservative has been added to the container, instruct the patient not to discard the preservative. Instruct the patient not to void directly into the container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom as a reminder to save all urine.
- ▶ Instruct the patient to void all urine into the collection device, then pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no fluid restrictions, unless by medical direction.
- ▶ Inform the patient that foods and medications listed under "Interfering

Factors” should be restricted by medical direction for at least 4 days before specimen collection.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions; assure foods and medications listed under “Interfering Factors” have been restricted for at least 4 days prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started, and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage. Conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the

specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.

- ▶ Include on the specimen collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that can affect test results. Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP. Consideration may be given to niacin supplementation and increased protein, if appropriate, for patients with abnormal findings. In some cases, the tumor may divert dietary tryptophan to serotonin, resulting in pellagra.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALP, amino acid screen, antibodies gliadin, biopsy intestine, biopsy lung, calcium, cancer antigens, capsule endoscopy, chloride sweat, fecal fat, folate, and GTT.
- ▶ Refer to the Endocrine, Gastrointestinal, and Immune System tables at the back of the book for related tests by body system.

Hypersensitivity Pneumonitis Serology

SYNONYM/ACRONYM: Farmer's lung disease serology, extrinsic allergic alveolitis.

SPECIMEN: Serum (2 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Immunodiffusion) Negative.

RESULT:

CRITICAL VALUES: N/A

Increased in:

• **Hypersensitivity Pneumonitis**

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

H

Hysterosalpingography

SYNONYM/ACRONYM: Uterography, uterosalpingography, hysteroqram.

AREA OF APPLICATION: Uterus and fallopian tubes.

CONTRAST: Iodinated contrast medium.

DESCRIPTION: Hysterosalpingography is performed as part of an infertility study to identify anatomic abnormalities of the uterus or occlusion of the fallopian tubes. The procedure allows visualization of the uterine cavity, fallopian tubes, and peritubal area after the injection of contrast medium into the cervix. The contrast medium should flow through the uterine cavity, through the fallopian tubes, and into the peritoneal cavity, where it is absorbed if no obstruction exists. Passage of the contrast medium through the tubes may clear mucous plugs, straighten kinked tubes, or break up

adhesions, thus restoring fertility. This procedure is also used to evaluate the fallopian tubes after tubal ligation and to evaluate the results of reconstructive surgery. Risks include uterine perforation, exposure to radiation, infection, allergic reaction to contrast medium, bleeding, and pulmonary embolism.

INDICATIONS:

- Confirm the presence of fistulas or adhesions
- Confirm tubal abnormalities such as adhesions and occlusions
- Confirm uterine abnormalities such as congenital malformation,

traumatic injuries, or the presence of foreign bodies

- Detect bicornate uterus
- Evaluate adequacy of surgical tubal ligation and reconstructive surgery

RESULT:

Normal findings in:

- Contrast medium flowing freely into the fallopian tubes and from the uterus into the peritoneal cavity
- Normal position, shape, and size of the uterine cavity



Abnormal findings in:


- Bicornate uterus
- Developmental abnormalities
- Extrauterine pregnancy
- Internal scarring
- Kinking of the fallopian tubes due to adhesions
- Partial or complete blockage of fallopian tube(s)
- Tumors
- Uterine cavity anomalies
- Uterine fistulas
- Uterine masses or foreign body
- Uterine fibroid tumors (leiomyomas)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients with bleeding disorders.
-  Patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.

-  Patients who are in renal failure.
- Patients with menses, undiagnosed vaginal bleeding, or pelvic inflammatory disease.
- Young patients (17 yr and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Insufficient injection of contrast medium
- Excessive traction during the test or tubal spasm, which may cause the appearance of a stricture in an otherwise normal fallopian tube

Other considerations:

- Excessive traction during the test may displace adhesions, making the fallopian tubes appear normal.
- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow pretesting preparations may cause the procedure to be canceled or repeated.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel remaining in the room with the patient should wear a protective lead apron. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the uterus and fallopian tubes.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, and contrast mediums.
- ▶ Obtain a history of the patient's reproductive and genitourinary systems and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent barium or other radiological contrast procedures. Ensure that barium studies were performed more than 4 days before the hysterosalpinography.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Explain to the patient that she may feel temporary sensations of nausea, dizziness, slow heartbeat, and menstrual-like cramping during the procedure, as well as shoulder pain from subphrenic irritation from the contrast medium as it spills into the peritoneal cavity. Inform the patient that the procedure is performed in a radiology department by a health care provider (HCP), with support staff, and takes approximately 30 to 60 min.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during and after the procedure.
- ▶ Instruct the patient to take a laxative or a cathartic, as ordered, on the evening before the examination.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid or medication restrictions, unless by medical direction or department protocol.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with pretesting preparations prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Assess for completion of bowel preparation according to the institution's procedure. Administer enemas or suppositories on the morning of the test, as ordered.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in a lithotomy position on the fluoroscopy table.
- ▶ A kidney, ureter, and bladder film is taken to ensure that no stool, gas, or barium will obscure visualization of the uterus and fallopian tubes.
- ▶ A speculum is inserted into the vagina, and contrast medium is introduced into the uterus through the cervix via a cannula, after which both fluoroscopic and radiographic images are taken.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications and activity, as directed by the HCP.
- ▶ Observe for delayed reaction to iodinated contrast medium, including rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Inform the patient that a vaginal discharge is common and that it may be bloody, lasting 1 to 2 days after the test.
- ▶ Inform the patient that dizziness and cramping may follow this procedure, and that analgesia may be given if there is persistent cramping. Instruct the patient to contact the HCP in the event of severe cramping or profuse bleeding.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CT abdomen, laparoscopy gynecological, MRI abdomen, US obstetric, US pelvis, and uterine fibroid embolization.
- ▶ Refer to the Genitourinary System table at the back of the book for related tests by body system.

Immunofixation Electrophoresis, Blood and Urine

SYNONYM/ACRONYM: IFE.

SPECIMEN: Serum (1 mL) collected in a red-top tube. Urine (10 mL) from a random or timed collection in a clean plastic container.

REFERENCE VALUE: (Method: Immunoprecipitation combined with electrophoresis) Test results are interpreted by a pathologist. Normal placement and intensity of staining provide information about the immunoglobulin bands.

DESCRIPTION: Immunofixation electrophoresis (IFE) is a qualitative technique that provides a detailed separation of individual immunoglobulins according to their electrical charges. Abnormalities are revealed by changes produced in the individual bands, such as displacement, color, or absence of color. Urine IFE has replaced the Bence Jones screening test for light chains. IFE has replaced immunoelectrophoresis because it is more sensitive and easier to interpret.

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase immunoglobulin levels include asparaginase, cimetidine, and narcotics.
- Drugs that may decrease immunoglobulin levels include dextran, oral contraceptives, methylprednisolone (high doses), and phenytoin.
- Chemotherapy and radiation treatments may alter the width of the bands and make interpretation difficult.

INDICATIONS:

- Assist in the diagnosis of multiple myeloma and amyloidosis
- Assist in the diagnosis of suspected immunodeficiency
- Assist in the diagnosis of suspected immunoproliferative disorders, such as multiple myeloma and Waldenström's macroglobulinemia
- Identify biclonal or monoclonal gammopathies
- Identify cryoglobulinemia
- Monitor the effectiveness of chemotherapy or radiation therapy

RESULT:

See monograph titled "Immunoglobulins A, D, G, and M."

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assess the immune system with respect to the type and quantity of immunoglobulins in blood and urine.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's hematopoietic and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Note any recent procedures that can interfere with test results. Assess whether the patient received any vaccinations or immunizations within the last 6 mo or any blood or blood components within the last 6 wk.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe

normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate specimen containers with the corresponding patient demographics, date, and time of collection.

Blood:

- ▶ Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

Urine:**Clean-Catch Specimen:**

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Blood or Urine:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in

relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

▶ Related tests include anion gap, biopsy bone, biopsy bone marrow, biopsy liver, biopsy lymph node, cold agglutinin, complete blood count, complete blood count, WBC count

and differential, cryoglobulin, ESR, fibrinogen, quantitative immunoglobulin levels, LAP, liver and spleen scan, β -2-microglobulin, platelet antibodies, protein total and fractions, and UA. Refer to the Hematopoietic and Immune System tables at the back of the book for related tests by body system.

Immunoglobulin E

SYNONYM/ACRONYM: IgE.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Age	Conventional Units	SI Units (Conventional Units \times 1)
Newborn	Less than 12 international units/mL	Less than 120 mg/L
Less than 1 yr	Less than 50 international units/mL	Less than 500 mg/L
2–4 yr	Less than 100 international units/mL	Less than 1000 mg/L
5 yr and older	Less than 300 international units/mL	Less than 3000 mg/L

DESCRIPTION: Immunoglobulin E (IgE) is an antibody whose primary response is to allergic reactions and parasitic infections. Most of the body's IgE is bound to specialized tissue cells; little is available in the circulating blood. IgE binds to the membrane of special granulocytes called *basophils* in the circulating blood and *mast cells* in the tissues. Basophil and mast cell membranes have receptors for IgE. Mast cells are abundant in the skin and the tissues lining the respiratory and alimentary tracts. When IgE

antibody becomes cross-linked with antigen/allergen, the release of histamine, heparin, and other chemicals from the granules in the cells is triggered. A sequence of events follows activation of IgE that affects smooth muscle contraction, vascular permeability, and inflammatory reactions. The inflammatory response allows proteins from the bloodstream to enter the tissues. Helminths (worm parasites) are especially susceptible to immunoglobulin-mediated cytotoxic chemicals. The inflammatory reaction

proteins attract macrophages from the circulatory system and granulocytes, such as eosinophils, from circulation and bone marrow. Eosinophils also contain enzymes effective against the parasitic invaders.

INDICATIONS:

Assist in the evaluation of allergy and parasitic infection

RESULT:

Increased in:
Conditions involving allergic reactions or infections that stimulate production of IgE.

- Alcoholism (*Alcohol may play a role in the development of environmentally instigated IgE mediated hypersensitivity*)
- Allergy
- Asthma
- Bronchopulmonary aspergillosis
- Dermatitis
- Eczema
- Hay fever
- IgE myeloma
- Parasitic infestation
- Rhinitis
- Sinusitis
- Wiskott-Aldrich syndrome

Decreased in:

- Advanced carcinoma (Generalized decrease in immune system response)
- Agammaglobulinemia (*Related to decreased production*)
- Ataxia-telangiectasia (*Familial immunodeficiency disorder*)
- IgE deficiency

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may cause a decrease in IgE levels include phenytoin and tryptophan.

- Penicillin G has been associated with increased IgE levels in some patients with drug-induced acute interstitial nephritis.
- Normal IgE levels do not eliminate allergic disorders as a possible diagnosis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess IgE levels in order to identify the presence of an allergic or inflammatory immune system response.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the

patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Increased IgE levels may be associated with allergy. Consideration should be given to diet if the patient has food allergies.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the patient's condition and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include allergen-specific IgE, alveolar/arterial gradient, biopsy intestine, biopsy liver, biopsy muscle, blood gases, carbon dioxide, complete blood count, eosinophil count, fecal analysis, hypersensitivity pneumonitis, lung perfusion scan, complete blood count, platelet count, PFT, and complete blood count, WBC count and differential.
- ▶ Refer to the Immune and Respiratory System tables at the back of the book for related tests by body system.

Immunoglobulins A, D, G, and M

SYNONYM/ACRONYM: IgA, IgD, IgG, and IgM.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Nephelometry)

Age	Conventional Units	SI Units
	<i>Immunoglobulin A (Conventional Units × 0.01)</i>	
Newborn	1–4 mg/dL	0.01–0.04 g/L
1–9 mo	2–80 mg/dL	0.02–0.80 g/L
10–12 mo	15–90 mg/dL	0.15–0.90 g/L
2–3 yr	18–150 mg/dL	0.18–1.50 g/L
4–5 yr	25–160 mg/dL	0.25–1.60 g/L
6–8 yr	35–200 mg/dL	0.35–2.00 g/L
9–12 yr	45–250 mg/dL	0.45–2.50 g/L
Older than 12 yr	40–350 mg/dL	0.40–3.50 g/L

(table continues on 736)

Age	Conventional Units	SI Units
<i>Immunoglobulin D (Conventional Units × 10)</i>		
Newborn	Greater than 2 mg/dL	Greater than 20 mg/L
Adult	Less than 15 mg/dL	Less than 150 mg/L
<i>Immunoglobulin G (Conventional Units × 0.01)</i>		
Newborn	650–1600 mg/dL	6.5–16 g/L
1–9 mo	250–900 mg/dL	2.5–9 g/L
10–12 mo	290–1070 mg/dL	2.9–10.7 g/L
2–3 yr	420–1200 mg/dL	4.2–12 g/L
4–6 yr	460–1240 mg/dL	4.6–12.4 g/L
Greater than 6 yr	650–1600 mg/dL	6.5–16 g/L
<i>Immunoglobulin M (Conventional Units × 0.01)</i>		
Newborn	Less than 25 mg/dL	Less than 0.25 g/L
1–9 mo	20–125 mg/dL	0.2–1.25 g/L
10–12 mo	40–150 mg/dL	0.4–1.5 g/L
2–8 yr	45–200 mg/dL	0.45–2.0 g/L
9–12 yr	50–250 mg/dL	0.5–2.5 g/L
Greater than 12 yr	50–300 mg/dL	0.5–3.0 g/L

DESCRIPTION: Immunoglobulins A, D, E, G, and M are made by plasma cells in response to foreign particles. Immunoglobulins neutralize toxic substances, support phagocytosis, and destroy invading microorganisms. They are made up of heavy and light chains. Immunoglobulins produced by the proliferation of a single plasma cell (clone) are called *monoclonal*. Polyclonal increases result when multiple cell lines produce antibody. IgA is found mainly in secretions such as tears, saliva, and breast milk. It is believed to protect mucous membranes from viruses and bacteria. The function of IgD is not well understood. For details on IgE, see the monograph titled “Immunoglobulin E.” IgG is the predominant serum immunoglobulin and is important in long-term defense against disease. It is the only antibody that crosses the placenta. IgM is the largest immunoglobulin, and it is the first antibody to react to an antigenic stimulus. IgM also

forms natural antibodies, such as ABO blood group antibodies. The presence of IgM in cord blood is an indication of congenital infection.

INDICATIONS:

- Assist in the diagnosis of multiple myeloma
- Evaluate humoral immunity status
- Monitor therapy for multiple myeloma
- IgA: Evaluate patients suspected of IgA deficiency prior to transfusion. Evaluate anaphylaxis associated with the transfusion of blood and blood products (anti-IgA antibodies may develop in patients with low levels of IgA, possibly resulting in anaphylaxis when donated blood is transfused)

RESULT:

Increased in:

IgA:

- Polyclonal:
Chronic liver disease (*Pathophysiology is not clear*)

Immunodeficiency states, such as Wiskott-Aldrich syndrome (*Inherited condition of lymphocytes characterized by increased IgA and IgE*)

Inflammatory bowel disease (*IgG and/or IgA antibody positive for Saccharomyces cerevisiae with negative perinuclear-antineutrophil cytoplasmic antibody is indicative of Crohn's disease*)

Lower gastrointestinal (GI) cancer (*Pathophysiology is not clear*)

Rheumatoid arthritis (*Pathophysiology is not clear*)

- Monoclonal:
IgA-type multiple myeloma (*Related to excessive production by a single clone plasma cells*)

IgD:

- Polyclonal: (*Pathophysiology is unclear but increases are associated with increases in IgM*)

Certain liver diseases

Chronic infections

Connective tissue disorders

- Monoclonal:
IgD-type multiple myeloma (*Related to excessive production by a single clone of plasma cells*)

IgG:

Conditions that involve inflammation and/or development of an infection stimulate production of IgG.

- Polyclonal:
Autoimmune diseases, such as systemic lupus erythematosus, rheumatoid arthritis, and Sjögren's syndrome
Chronic liver disease
Chronic or recurrent infections
Intrauterine devices (*The IUD creates a localized inflammatory reaction that stimulates production of IgG*)
Sarcoidosis
- Monoclonal:
IgG-type multiple myeloma (*Related to excessive production by a single clone of plasma cells*)

Leukemias

Lymphomas

IgM:

- Polyclonal: (*Humoral response to infections and inflammation; both acute and chronic*)

Active sarcoidosis

Chronic hepatocellular disease

Collagen vascular disease

Early response to bacterial or parasitic infection

Hyper-IgM dysgammaglobulinemia

Rheumatoid arthritis

Variable in nephrotic syndrome

Viral infection (hepatitis or mononucleosis)

- Monoclonal:
Cold agglutinin hemolysis disease
Malignant lymphoma
Neoplasms (especially in GI tract)
Reticulosis
Waldenström's macroglobulinemia (*Related to excessive production by a single clone of plasma cells*)

Decreased in:

IgA:

- Ataxia-telangiectasia
- Chronic sinopulmonary disease
- Genetic IgA deficiency

IgD:

- Genetic IgD deficiency
- Malignant melanoma of the skin
- Pre-eclampsia

IgG:

- Burns
- Genetic IgG deficiency
- Nephrotic syndrome
- Pregnancy

IgM:

- Burns
- Secondary IgM deficiency associated with IgG or IgA gammopathies

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase immunoglobulin levels include asparaginase, cimetidine, and narcotics.
- Drugs that may decrease immunoglobulin levels include dextran, oral contraceptives, methylprednisolone (high doses), and phenytoin.
- Chemotherapy, immunosuppressive therapy, and radiation treatments decrease immunoglobulin levels.
- Specimens with macroglobulins, cryoglobulins, or cold agglutinins tested at cold temperatures may give falsely low values.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess the immune system with respect to the quantity of immunoglobulin levels present in the blood.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's GI, hematopoietic, immune, and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, anion gap, ANA, bilirubin, biopsy bone, biopsy bone marrow, biopsy liver, biopsy lymph node, blood groups and antibodies, cold agglutinin, complete blood count, Coomb's antiglobulin (direct and indirect), cryoglobulin, ESR, fibrinogen, IFE, quantitative immunoglobulin levels, GGT, LAP, liver and spleen scan, beta-2-microglobulin, platelet antibodies, protein total and fractions, RF, UA, and complete blood count, WBC count and differential.
- ▶ Refer to the Gastrointestinal, Hematopoietic, Immune, and Musculoskeletal System tables at the back of the book for related tests by body system.

Immunosuppressants: Cyclosporine, Methotrexate

SYNONYM/ACRONYM: Cyclosporine (Sandimmune), methotrexate (MTX, amethopterin, Folex, Rheumatrex), methotrexate sodium (Mexate).

SPECIMEN: Whole blood (1 mL) collected in lavender-top tube for cyclosporine. Serum (1 mL) collected in a red-top tube for methotrexate.

Immunosuppressant	Route of Administration	Recommended Collection Time
Cyclosporine	Oral	12 hr after dose
Methotrexate	Oral Intramuscular	Varies according to dosing protocol Varies according to dosing protocol

Important note: This information must be clearly and accurately communicated to avoid misunderstanding of the dose time in relation to the collection time. Miscommunication between the individual administering the medication and the individual collecting the specimen is the most frequent cause of subtherapeutic levels, toxic levels, and misleading information used in calculation of future doses.

REFERENCE VALUE: (Method: Immunoassay)

	Therapeutic Dose	SI Units (Conventional Units × 0.832)	Half-Life	Volume of Distribution	Protein Binding	Excretion
Cyclosporine	100–250 ng/mL Renal transplant	83–208 nmol/L	8–24 hr	4–6 L/kg	90%	Renal
	100–400 ng/mL Cardiac transplant	83–333 nmol/L	8–24 hr	4–6 L/kg	90%	Renal
	100–300 ng/mL Bone marrow transplant	83–250 nmol/L	8–24 hr	4–6 L/kg	90%	Renal
	100–400 ng/mL transplant	83–333 nmol/L	8–24 hr	4–6 L/kg	90%	Renal
Methotrexate	0.01–5.00 micromol/L*		8–15 hr L/kg	0.4–1.0	50–70%	Renal

*Dependent on therapeutic approach.

DESCRIPTION: Cyclosporine is an immunosuppressive drug used in the management of organ rejection, especially rejection of heart, liver, and kidney transplants. Its most serious side effect is renal impairment or renal failure. Methotrexate is a highly toxic drug that causes cell death by disrupting DNA synthesis.

Many factors must be considered in effective dosing and monitoring of therapeutic drugs, including patient age, weight, interacting medications, electrolyte balance, protein levels, water balance, and conditions that affect absorption and excretion, as well as foods, herbals, vitamins, and minerals that can either potentiate or inhibit the intended target concentration.

INDICATIONS:

Cyclosporine:

- Assist in the management of treatments to prevent organ rejection
- Monitor for toxicity


Methotrexate:

- Monitor effectiveness of treatment of cancer and some autoimmune disorders
- Monitor for toxicity

RESULT:

Normal levels	Therapeutic effect
Toxic levels	Adjust dose as indicated
Cyclosporine	Renal impairment
Methotrexate	Renal impairment

CRITICAL VALUES:

 It is important to note the adverse effects of toxic and subtherapeutic levels. Care must be taken to investigate signs and symptoms of too little

and too much medication. Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms.

Cyclosporine: Greater than 400 ng/mL

Signs and symptoms of cyclosporine toxicity include increased severity of expected side effects, which include nausea, stomatitis, vomiting, anorexia, hypertension, infection, fluid retention, hypercalcemic metabolic acidosis, tremor, seizures, headache, and flushing. Possible interventions include close monitoring of blood levels to make dosing adjustments, inducing emesis (if orally ingested), performing gastric lavage (if orally ingested), withholding the drug, and initiating alternative therapy for a short time until the patient is stabilized.

Methotrexate: Greater than 5.00 micromol/L after 24 hr; greater than 0.50 micromol/L after 48 hr; greater than 0.05 micromol/L after 72 hr

Signs and symptoms of methotrexate toxicity include increased severity of expected side effects, which include nausea, stomatitis, vomiting, anorexia, bleeding, infection, bone marrow depression, and, over a prolonged period of use, hepatotoxicity. The effect of methotrexate on normal cells can be reversed by administration of 5-formyltetrahydrofolate (citrovorum or leucovorin). 5-Formyltetrahydrofolate allows higher doses of methotrexate to be given.

INTERFERING FACTORS:

- Numerous drugs interact with cyclosporine and either increase cyclosporine levels or increase the risk of toxicity. These drugs include acyclovir, aminoglycosides, amiodarone, amphotericin B, anabolic steroids, cephalosporins, cimetidine, danazol, erythromycin, furosemide, ketoconazole,

melphalan, methylprednisolone, miconazole, NSAIDs, oral contraceptives, and trimethoprim-sulfamethoxazole.

- Drugs that may decrease cyclosporine levels include carbamazepine, ethotoin, mephenytoin, phenobarbital, phenytoin, primidone, and rifampin.
- Drugs that may increase methotrexate levels or increase the risk of toxicity include NSAIDs, probenecid, salicylate, and sulfonamides.
- Antibiotics may decrease the absorption of methotrexate.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to monitor for therapeutic and toxic drug levels.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Consider recommended collection time with regard to dosing schedule. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ *Nutritional considerations:* Patients taking immunosuppressant therapy tend to have decreased appetites due to the side effects of the medication. Instruct patients to consume a variety of foods within the basic food groups, maintain a healthy weight, be physically active, limit salt intake, limit alcohol intake, and be a nonsmoker.
- ▶ Recognize anxiety related to test results, and offer support. Patients receiving these drugs usually have conditions that can be intermittently moderately to severely debilitating, resulting in significant lifestyle changes. Educate the patient regarding access to counseling services, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain to the patient the importance of following the medication regimen and give instructions regarding drug interactions. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient to be prepared to provide the pharmacist with a list of other medications he or she is already taking in the event that the requesting HCP prescribes a medication.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include BUN and creatinine.
- ▶ Refer to the Genitourinary and Immune System tables at the back of the book for related tests by body system.

I Infectious Mononucleosis Screen

SYNONYM/ACRONYM: Monospot, heterophil antibody test, IM serology.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Agglutination) Negative.

DESCRIPTION: Infectious mononucleosis is caused by the Epstein-Barr virus (EBV). The incubation period is 10 to 50 days, and the symptoms last 1 to 4 wk after the infection has fully developed. The hallmark of EBV infection is the presence of heterophil antibodies, also called *Paul-Bunnell-Davidsohn antibodies*, which are immunoglobulin M (IgM) antibodies that agglutinate sheep or horse red blood cells. The disease induces formation of abnormal lymphocytes in the lymph nodes; stimulates increased formation of heterophil antibodies; and is

characterized by fever, cervical lymphadenopathy, tonsillopharyngitis, and hepatosplenomegaly. EBV is also thought to play a role in Burkitt's lymphoma, nasopharyngeal carcinoma, and chronic fatigue syndrome. If the results of the heterophil antibody screening test are negative and infectious mononucleosis is highly suspected, EBV-specific serology should be requested.

INDICATIONS:

- Assist in confirming infectious mononucleosis

RESULT:**Positive findings in:**

Infectious mononucleosis

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- False-positive results may occur in the presence of narcotic addiction, serum sickness, lymphomas, hepatitis, leukemia, cancer of the pancreas, and phenytoin therapy.
- A false-negative result may occur if treatment was begun before antibodies developed or if the test was done less than 6 days after exposure to the virus.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of mononucleosis infection.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex. Obtain a history of exposure.
- ▶ Obtain a history of the patient's hepatobiliary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent therapies that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately

5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Inform the patient that approximately 10% of all results are false-negative or false-positive. Inform the patient that signs and symptoms of infection include fever, chills, sore throat, enlarged lymph nodes, and fatigue. Self-care while the disease runs its course includes adequate fluid and nutritional intake along with sufficient rest. Activities that cause fatigue or stress should be avoided.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Advise the patient to refrain from direct contact with others because the disease is transmitted through saliva. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease

process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include complete blood count with peripheral blood smear evaluation.
- Refer to the Hepatobiliary and Immune System tables at the back of the book for related tests by body system.

I Insulin and Insulin Response to Glucose

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

	Insulin	SI Units (Conventional Units × 6.945)	Tolerance for Glucose (Hypoglycemia)
Fasting	Less than 25 micro international units/L	Less than 174 pmol/L	65–115 mg/dL
30 min	30–230 micro international units/L	208–1597 pmol/L	N/A
1 hr	18–276 micro international units/L	125–1917 pmol/L	Less than 200 mg/dL
2 hr	16–166 micro international units/L	111–1153 pmol/L	Less than 140 mg/dL
3 hr	Less than 25 micro international units/L	Less than 174 pmol/L	65–120 mg/dL
4 hr	Less than 25 micro international units/L	Less than 174 pmol/L	65–120 mg/dL
5 hr	Less than 25 micro international units/L	Less than 174 pmol/L	65–115 mg/dL

DESCRIPTION: Insulin is secreted in response to elevated blood glucose, and its overall effect is to promote glucose use and energy storage. The insulin response test measures the rate of insulin secreted by the beta cells of the islets of Langerhans in the pancreas; it may be performed simultaneously with a 5-hr glucose tolerance test for hypoglycemia.

INDICATIONS:

- Assist in the diagnosis of early or developing non-insulin-dependent (type 2) diabetes, as indicated by excessive production of insulin in relation to blood glucose levels (best shown with glucose tolerance tests or 2-hr postprandial tests)
 - Assist in the diagnosis of insulinoma, as indicated by sustained high levels of insulin and absence of blood glucose-related variations
 - Confirm functional hypoglycemia, as indicated by circulating insulin levels appropriate to changing blood glucose levels
 - Differentiate between insulin-resistant diabetes, in which insulin levels are high, and non-insulin-resistant diabetes, in which insulin levels are low
 - Evaluate fasting hypoglycemia of unknown cause
 - Evaluate postprandial hypoglycemia of unknown cause
 - Evaluate uncontrolled insulin-dependent (type 1) diabetes
- Alcohol use (*Stimulates insulin production*)
 - Cushing's syndrome (*Overproduction of cortisol increases insulin levels*)
 - Excessive administration of insulin
 - Insulin- and proinsulin-secreting tumors (insulinomas)
 - Obesity (*Related to development of insulin resistance; body does not respond to insulin being produced*)
 - Persistent hyperinsulinemic hypoglycemia (*Collection of hypoglycemic disorders of infants and children*)
 - Reactive hypoglycemia in developing diabetes
 - Severe liver disease

Decreased in:

- Beta cell failure (*Pancreatic beta cells produce insulin, therefore damage to these cells will decrease insulin levels*)
- Insulin-dependent diabetes (*Related to lack of endogenous insulin*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may increase insulin levels include acetoexamide, alanine, albuterol, amino acids, beclomethasone, betamethasone, broxaterol, calcium gluconate, cannabis, chlorpropamide, cyclic AMP, glibornuride, glipizide, glisoxepide, glucagon, glyburide, ibopamine, insulin, insulin-like growth factor-I, oral contraceptives, pancreozymin, prednisolone, prednisone, rifampin, salbutamol, terbutaline, tolazamide, tolbutamide, trichlormethiazide, and verapamil.
- Drugs that may decrease insulin levels include acarbose, asparaginase, calcitonin, cimetidine,

RESULT:

Increased in:

- Acromegaly (*Excess production of growth hormone increases insulin levels*)

- clofibrate, dexfenfluramine, diltiazem, doxazosin, enalapril, enprostil, ether, hydroxypropyl methylcellulose, insulin-like growth factor–I, metformin (Glucophage), niacin, nifedipine, nitrendipine, octreotide, phenytoin, propranolol, and psyllium.
- Administration of insulin or oral hypoglycemic agents within 8 hr of the test can lead to falsely elevated levels.
 - Hemodialysis destroys insulin and affects test results.
 - Recent radioactive scans or radiation can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the evaluation of fasting hypoglycemia.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Inform the patient that multiple specimens may be required. Inform the patient that specimen collection takes approximately 5 to

10 min. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ If a single sample is to be collected, the patient should have fasted and refrained, with medical direction, from taking insulin or other oral hypoglycemic agents for at least 8 hr before specimen collection. Protocols may vary from facility to facility.
- ▶ **Hypoglycemia:** Serial specimens for insulin levels are collected in conjunction with glucose levels after administration of a 100-g glucose load. The patient should be prepared as for a standard oral glucose tolerance test over a 5-hr period. Protocols may vary from facility to facility.
- ▶ There are no fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions and other pretesting preparations; assure that food or medications have been restricted as instructed prior to the specific procedure's protocol.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and medication, as directed by the HCP.
- ▶ **Nutritional considerations:** Increased insulin levels may be associated with diabetes. The nutritional needs of each diabetic patient need to be determined individually (especially during pregnancy) by a health care professional trained in nutrition. Patients who adhere to dietary recommendations report a better general feeling of health, better weight management, greater control of glucose and lipid values, and improved use of insulin. There is no “diabetic diet”; however, many meal-planning approaches with nutritional goals are endorsed by the American Dietetic Association.
- ▶ Impaired glucose tolerance may be associated with diabetes. Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy).
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient’s lifestyle. Provide teaching and information

regarding the clinical implications of the test results, as appropriate. Emphasize, as appropriate, that good glycemic control delays the onset of and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Diabetes Association (www.diabetes.org).

- ▶ Reinforce information given by the patient’s HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient’s symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, ALT, angiography adrenal, bilirubin, BUN, calcium, catecholamines, cholesterol (HDL, LDL, total), cortisol, C-peptide, DHEA, creatinine, fecal analysis, fecal fat, fructosamine, GGT, gastric emptying scan, glucagon, glucose, GTT, glycated hemoglobin, GH, HVA, insulin antibodies, ketones, lipoprotein electrophoresis, metanephrines, microalbumin, and myoglobin.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Insulin Antibodies

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay) Less than 3%; includes binding of human, beef, and pork insulin to antibodies in patient's serum.

DESCRIPTION: The most common anti-insulin antibody is immunoglobulin (Ig) G, but IgA, IgM, IgD, and IgE antibodies also have anti-insulin properties. These antibodies usually do not cause clinical problems, but they may complicate insulin assay testing. IgM is thought to participate in insulin resistance and IgE in insulin allergy. Improvements in the purity of animal insulin and increased use of human insulin have resulted in a significant decrease in the incidence of insulin antibody formation.

INDICATIONS:

- Assist in confirming insulin resistance
- Assist in determining if hypoglycemia is caused by insulin abuse
- Assist in determining insulin allergy

RESULT:

Increased in:

- Factitious hypoglycemia (*Assists in differentiating lack of response due to the presence of insulin antibodies from secretive self-administration of insulin*)
- Insulin allergy or resistance (*Antibodies bind to insulin and decrease amount of free*

insulin available for glucose metabolism)

- Polyendocrine autoimmune syndromes
- Steroid-induced diabetes (*A side effect of treatment for systemic lupus erythematosus*)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Recent radioactive scans or radiation can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to assist in the prediction, diagnosis, and management of type I diabetes.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's endocrine and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Note any recent procedures that can interfere with test results.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and medication, as directed by the HCP.
- ▶ *Nutritional considerations:* The nutritional needs of each diabetic patient need to be determined individually (especially

during pregnancy) by a health care professional trained in nutrition. Patients who adhere to dietary recommendations report a better general feeling of health, better weight management, greater control of glucose and lipid values, and improved use of insulin. There is no "diabetic diet"; however, many meal-planning approaches with nutritional goals are endorsed by the American Dietetic Association.

- ▶ Impaired glucose tolerance may be associated with diabetes. Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy).
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Emphasize, as appropriate, that good glycemic control delays the onset of and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Diabetes Association (www.diabetes.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include C-peptide, glucose, GTT, and insulin.
- ▶ Refer to the Endocrine and Immune System tables at the back of the book for related tests by body system.

Intraocular Muscle Function

SYNONYM/ACRONYM: IOM function.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: Evaluation of ocular motility is performed to detect and measure muscle imbalance in conditions classified as heterotropias or heterophorias.

This evaluation is performed in a manner to assess fixation of each eye, alignment of both eyes in all directions, and the ability of both eyes to work together binocularly. Heterophorias are latent ocular deviations kept in check by the binocular power of fusion, and made intermittent by disrupting fusion. Heterotropias are conditions that manifest constant ocular deviations. The prefixes *eso-* (tendency for the eye to turn in), *exo-* (tendency for the eye to turn out), and *hyper-* (tendency for one eye to turn up) indicate the direction in which the affected eye moves spontaneously.

Strabismus is the failure of both eyes to spontaneously fixate on the same object because of a muscular imbalance (crossed eyes). *Amblyopia*, or lazy eye, is a term used for loss of vision in one or both eyes that cannot be attributed to an organic pathological condition of the eye or optic nerve. There are six extraocular muscles in each eye whose movement is controlled by three nerves. The actions of the muscles vary depending on the position of the eye when they

become innervated. The cover test is commonly used because it is reliable, easy to perform, and does not require special equipment. The cover test method is described in this monograph.

Another method for evaluation of ocular muscle function is the corneal light reflex test. It is useful with patients who cannot cooperate for prism cover testing or for patients who have poor fixation.

INDICATIONS:

- Detection and evaluation of extraocular muscle imbalance

RESULT:

The examiner should determine the range of ocular movements in all gaze positions, usually to include up and out, in, down and out, up and in, down and in, and out. Limited movements in gaze position can be recorded semiquantitatively as -1 (minimal), -2 (moderate), -3 (severe), or -4 (total).

Normal findings in:

- Normal range of ocular movements in all gaze positions.

Abnormal findings in:

- Amblyopia
- Heterophorias
- Heterotropias
- Strabismus

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- Inability of the patient to cooperate and remain still during the test because of age, significant pain, or mental status may interfere with the test results.
- Rubbing or squeezing the eyes may affect results.

**NURSING IMPLICATIONS
AND PROCEDURE**

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure evaluates extraocular muscle function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially latex.
- ▶ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that no discomfort will be experienced during the test. Inform the patient that a health care provider (HCP) performs the test in a quiet room, and that to evaluate both eyes, the test can take 2 to 4 min.
- ▶ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ▶ One eye is tested at a time. The patient is given a fixation point, usually the testing personnel's index finger. An object, such as a small toy, can be used to ensure fixation in pediatric patients. The patient is asked to follow the fixation point with his or her gaze in the direction the fixation point moves. When testing is completed, the procedure is repeated using the other eye. The procedure is performed at distance and near, first with and then without corrective lenses.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to vision loss, anticipated loss of driving privileges, or the possibility of requiring corrective lenses (self-image).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Educate the patient, as appropriate, that he or she may be referred for special therapy to correct the anomaly, which may include glasses, prisms, eye exercises, eye patches, or chemical patching with drugs that modify the focusing power of the eye. The patient and family should be educated that the chosen therapy involves a process of mental retraining. The mode of therapy in itself does not correct vision. It is the process by which the brain becomes readapted to accept, receive, and store visual images received by the eye that results in vision correction. Therefore,

the patient must be prepared to be alert, cooperative, and properly motivated. Answer any questions or address any concerns voiced by the patient or family.

- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change

in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include refraction and slit-lamp biomicroscopy.
- Refer to the Ocular System table at the back of the book for related tests by body system.

Intraocular Pressure

SYNONYM/ACRONYM: IOP.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: The intraocular pressure (IOP) of the eye depends on a number of factors. The two most significant are the amount of aqueous humor present in the eye and the circumstances by which it leaves the eye. Other physiological variables that affect IOP include respiration, pulse, and the degree of hydration of the body. Individual eyes respond to IOP differently. Some can tolerate high pressures (20 to 30 mm Hg), and some will incur optic nerve damage at lower pressures. With respiration, variations of up to 4 mm Hg in IOP can occur, and changes of 1 to 2 mm Hg occur with every pulsation of the central retinal artery. IOP is measured with a tonometer; normal values indicate the pressure at which no damage is done to the intraocular contents.

The rate of fluid leaving the eye, or its ability to leave the eye unimpeded, is the most important factor regulating IOP. There are three primary conditions that result in occlusion of the outflow channels for fluid. The most common condition is open-angle glaucoma, in which the diameter of the openings of the trabecular meshwork becomes narrowed, resulting in an increased IOP due to an increased resistance of fluid moving out of the eye. In secondary glaucoma, the trabecular meshwork becomes occluded by tumor cells, pigment, red blood cells in hyphema, or other material. Additionally, the obstructing material may cover parts of the meshwork itself, as with scar tissue or other types of adhesions that form after severe iritis, an angle-closure glaucoma attack, or a central retinal vein

occlusion. The third condition impeding fluid outflow in the trabecular channels occurs with pupillary block, most commonly associated with primary angle-closure glaucoma. In eyes predisposed to this condition, dilation of the pupil causes the iris to fold up like an accordion against the narrow-angle structures of the eye. Fluid in the posterior chamber has difficulty circulating into the anterior chamber; therefore, pressure in the posterior chamber increases, causing the iris to bow forward and obstruct the outflow channels even more. Angle-closure attacks occur quite suddenly and therefore do not give the eye a chance to adjust itself to the sudden increase in pressure. The eye becomes very red, the cornea edematous (patient may report seeing halos), and the pupil fixed and dilated, accompanied by a complaint of moderate pain. Pupil dilation can be initiated by emotional arousal or fear, conditions in which the eye must adapt to darkness (movie theaters), or mydriatics. Angle-closure glaucoma is an ocular emergency resolved by a peripheral iridectomy to allow movement of fluid between the anterior and posterior chambers. This procedure constitutes removal of a portion of the peripheral iris either by surgery or by use of an argon or yttrium-aluminum-garnet (YAG) laser.

INDICATIONS:

- Diagnosis or ongoing monitoring of glaucoma
- Screening test included in a routine eye examination

RESULT:

Normal findings in:

- Normal IOP is between 13 and 22 mm Hg.

Abnormal findings in:

- Open-angle glaucoma
- Primary angle-closure glaucoma
- Secondary glaucoma

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Inability of the patient to remain still and cooperative during the test may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure measures intraocular pressure (IOP) of the eye.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to topical anesthetic eye drops.
- ▶ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Explain that the patient will be requested to fixate the eyes during the procedure. Address concerns about

pain and explain that he or she may feel coldness or a slight sting when the anesthetic drops are instilled at the beginning of the procedure, but that no discomfort will be experienced during the test. Instruct the patient as to what should be expected with the use of the tonometer. The patient will experience less anxiety if he or she understands that the tonometer tip will touch the tear film and not the eye directly. Inform the patient that a health care provider (HCP) performs the test in a quiet, darkened room, and that to evaluate both eyes, the test can take 1 to 3 min.

- ▶ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because any movement, such as coughing, breathe holding, or wandering eye movements, produces unreliable results.
- ▶ Seat the patient comfortably. Instruct the patient to look at directed target while the eyes are examined.
- ▶ Instill ordered topical anesthetic in each eye, as ordered, and allow time for it to work. Topical anesthetic drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semitransparent area of the eyeball where the cornea and sclera meet). Neither dropper nor bottle should touch the eyelashes.
- ▶ Instruct the patient to look straight ahead, keeping the eyes open and unblinking.
- ▶ A number of techniques are used to measure intraocular pressure.

Intraocular pressure can be measured at the slit lamp or with a miniaturized, handheld applanation tonometer or an airpuff tonometer.

- ▶ When the applanation tonometer is positioned on the patient's cornea, the instrument's headrest is placed against the patient's forehead. The tonometer should be held at an angle with the handle slanted away from the patient's nose. The tonometer tip should not touch the eyelids.
- ▶ When the tip is properly aligned and in contact with the fluorescein-stained tear film, force is applied to the tip using an adjustment control to the desired endpoint. The tonometer is removed from the eye. The reading is taken a second time and, if the pressure is elevated, a third reading is taken. The procedure is repeated on the other eye.
- ▶ With the airpuff tonometer, an air pump blows air onto the cornea, and the time it takes for the air puff to flatten the cornea is detected by infrared light and photoelectric cells. This time is directly related to the intraocular pressure.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to vision loss or anticipated loss of driving privileges. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide contact information, if desired, for the Glaucoma Research Foundation (www.glaucoma.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications, usually eye drops, that are intended to decrease intraocular pressure. Explain the

importance of adhering to the therapy regimen, especially since increased intraocular pressure does not present symptoms. Instruct the patient in both the ocular side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include fundus photography, gonioscopy, nerve fiber analysis, slit-lamp biomicroscopy, and visual field testing.
- ▶ Refer to the Ocular System table at the back of the book for related tests by body system.

Intravenous Pyelography

SYNONYM/ACRONYM: Excretory urography (EUG), intravenous urography (IVU, IUG), IVP.

AREA OF APPLICATION: Kidneys, ureters, bladder, and renal pelvis.

CONTRAST: IV radiopaque iodine-based contrast medium.

DESCRIPTION: Intravenous pyelography (IVP) is the most commonly performed test to determine urinary tract dysfunction or renal disease. IVP uses IV radiopaque contrast medium to visualize the kidneys, ureters, bladder, and renal pelvis. The contrast medium concentrates in the blood and is filtered out by the glomeruli; it passes out through the renal tubules and is concentrated in the urine. Renal function is reflected by the length of time it takes the contrast medium to appear and to be excreted by each kidney. A series of images is performed during a 30-min period to view

passage of the contrast through the kidneys and ureters into the bladder. Tomography may be employed during the examination to permit the examination of an individual layer or plane of the organ that may be obscured by surrounding overlying structures.

INDICATIONS:

- Aid in the diagnosis of renovascular hypertension
- Evaluate the cause of blood in the urine
- Evaluate the effects of urinary system trauma

- Evaluate function of the kidneys, ureters, and bladder
- Evaluate known or suspected ureteral obstruction
- Evaluate the presence of renal, ureter, or bladder calculi
- Evaluate space-occupying lesions or congenital anomalies of the urinary system

RESULT:

Normal findings in:

- Normal size and shape of kidneys, ureters, and bladder
- Normal bladder and absence of masses or renal calculi, with prompt visualization of contrast medium through the urinary system


Abnormal findings in:

- Absence of a kidney (congenital malformation)
- Benign and malignant kidney tumors
- Bladder tumors
- Congenital renal or urinary tract abnormalities
- Glomerulonephritis
- Hydronephrosis
- Prostatic enlargement
- Pyelonephritis
- Renal cysts
- Renal hematomas
- Renal or ureteral calculi
- Soft-tissue masses
- Tumors of the collecting system



CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the contrast medium may benefit from premedication with corticosteroids

or the use of nonionic contrast medium.

- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Patients with renal insufficiency, indicated by a BUN value greater than 40 mg/dL or creatinine value greater than 1.5 mg/dL, because contrast medium can complicate kidney function.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.
- Patients with multiple myeloma, who may experience decreased kidney function subsequent to administration of contrast medium.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.

- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel remaining in the room with the patient should wear a protective lead apron. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- Inform the patient that the procedure assesses the kidneys, ureters, and bladder.
- Obtain a history of the patient's complaints or symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- Obtain a history of the patient's GI and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Ensure that the results of blood tests are obtained and recorded before the procedure, especially BUN and creatinine.
- Note any recent barium or other radiological contrast procedures. Ensure that barium studies were performed more than 4 days before the IVP.
- Record the date of the last menstrual period and determine the possibility of

pregnancy in perimenopausal women.

- Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- If contrast media is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a radiology department by a HCP, and takes approximately 30 to 60 min.
- *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- Instruct the patient to take a laxative or a cathartic, as ordered, on the evening before the examination.
- Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- Ensure the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- Assess for completion of bowel preparation according to the institution's procedure. Administer enemas

or suppositories on the morning of the test, as ordered.

- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table.
- ▶ A kidney, ureter, and bladder (KUB) or plain film is taken to ensure that no barium or stool obscures visualization of the urinary system.
- ▶ Insert an IV line, if one is not already in place, and inject the contrast medium.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Images are taken at 1, 5, 10, 15, 20, and 30 min following injection of the contrast medium into the urinary system. Instruct the patient to exhale deeply and to hold his or her breathe while each image is taken.
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.
- ▶ Instruct the patient to void if a postvoiding exposure is required to visualize the empty bladder.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity,

as directed by the HCP. Renal function should be assessed before metformin is resumed, if contrast was used.

- ▶ Observe for delayed reaction to iodinated contrast medium, including rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Monitor urinary output after the procedure. Decreased urine output may indicate impending renal failure.
- ▶ Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bladder, biopsy kidney, biopsy prostate, BUN, CT abdomen, CT pelvis, creatinine, cystometry, cystoscopy, gallium scan, KUB, MRI abdomen, renogram, retrograde ureteropyelography, US bladder, US kidney, US prostate, urine markers of bladder cancer, urinalysis, urine cytology, and voiding cystourethrography.
- ▶ Refer to the Genitourinary System table at the back of the book for related tests by body system.

Intrinsic Factor Antibodies

SYNONYM/ACRONYM: IF antibodies.

SPECIMEN: Serum (1 mL) collected in a red-top tube. Plasma (1 mL) collected in a lavender-top (EDTA) tube is also acceptable.

REFERENCE VALUE: (Method: Radioimmunoassay) None detected.

DESCRIPTION: Intrinsic factor (IF) is produced by the parietal cells of the gastric mucosa and is required for the normal absorption of vitamin B₁₂. In some diseases, antibodies are produced that bind to the cobalamin-IF complex, prevent the complex from binding to ileum receptors, and prevent vitamin B₁₂ absorption. There are two types of antibodies: type 1, the more commonly present blocking antibody; and type 2, the binding antibody. The blocking antibody inhibits uptake of vitamin B₁₂ at the binding site of IF. Binding antibody combines with either free or complexed IF.

- Some patients with insulin-dependent (type 1) diabetes

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Recent treatment with methotrexate or another folic acid antagonist can interfere with test results.
- Vitamin B₁₂ injected or ingested within 48 hr of the test invalidates results.
- Recent radioactive scans or radiation can interfere with test results when radioimmunoassay is the test method.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

INDICATIONS:

- Assist in the diagnosis of pernicious anemia
- Evaluate patients with decreased vitamin B₁₂ levels

RESULT:

Increased in:

Conditions that involve the production of these blocking and binding autoantibodies.

- Megaloblastic anemia
- Pernicious anemia
- Some patients with hyperthyroidism

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the investigation of suspected pernicious anemia.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's hematopoietic and gastrointestinal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction. Administration of vitamin B₁₂ should be withheld within 48 hr before testing.

INTRATEST:

- ▶ Ensure that vitamin B₁₂ has been withheld within 48 hr before testing.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient

- demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies antithyroglobulin and antithyroid peroxidase, biopsy bone marrow, complete blood count, complete blood count, RBC indices, folic acid, and vitamin B₁₂.
- ▶ Refer to the Hematopoietic and Gastrointestinal System tables at the back of the book for related tests by body system.

Iron

SYNONYM/ACRONYM: Fe.**SPECIMEN:** Serum (1 mL) collected in a red- or tiger-top tube.**REFERENCE VALUE:** (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 0.179)
Newborn	100–250 mcg/dL	17.9–44.8 micromol/L
Infant–9 yr	20–105 mcg/dL	3.6–18.8 micromol/L
10–14 yr	20–145 mcg/dL	3.6–26.0 micromol/L
Adult		
Male	65–175 mcg/dL	11.6–31.3 micromol/L
Female	50–170 mcg/dL	9–30.4 micromol/L

DESCRIPTION: Iron plays a principal role in erythropoiesis. Iron is necessary for the proliferation and maturation of red blood cells (RBCs) and is required for hemoglobin (Hgb) synthesis. Of the body's normal 4 g of iron, approximately 65% resides in Hgb and 3% in myoglobin. A small amount is also found in cellular enzymes that catalyze the oxidation and reduction of iron. The remainder of iron is stored in the liver, bone marrow, and spleen as ferritin or hemosiderin. Any iron present in the serum is in transit among the alimentary tract, the bone marrow, and available iron storage forms. Iron travels in the bloodstream bound to transferrin, a protein manufactured by the liver. Normally, iron enters the body by oral ingestion; only 10% is absorbed, but up to 20% can be absorbed in patients with iron-deficiency anemia. Unbound iron is highly toxic, but there is generally an excess of transferrin available to prevent the buildup of unbound iron in the circulation. Iron overload is as clinically significant as iron deficiency, especially in the accidental poisoning of children caused by excessive intake of iron-containing multivitamins.

INDICATIONS:

- Assist in the diagnosis of blood loss, as evidenced by decreased serum iron
- Assist in the diagnosis of hemochromatosis or other disorders of iron metabolism and storage
- Determine the differential diagnosis of anemia
- Determine the presence of disorders that involve diminished protein synthesis or defects in iron absorption
- Evaluate accidental iron poisoning
- Evaluate iron overload in dialysis patients or patients with transfusion-dependent anemias
- Evaluate thalassemia and sideroblastic anemia
- Monitor hematological responses during pregnancy, when serum iron is usually decreased
- Monitor response to treatment for anemia

RESULT:

Increased in:

- Acute iron poisoning (children) (*Related to excessive intake*)
- Acute leukemia
- Acute liver disease (*Possibly related to decrease in synthesis of iron storage proteins by damaged liver; iron accumulates and levels increase*)
- Aplastic anemia (*Increase is related to repeat blood transfusions*)

- Excessive iron therapy (*Related to excessive intake*)
- Hemochromatosis (*Inherited disorder of iron overload; the iron is not excreted in proportion to the rate of accumulation*)
- Hemolytic anemias (*Iron is released from lysed RBCs*)
- Lead toxicity (*Lead can biologically mimic iron, displace it, and release it into circulation where its concentration increases*)
- Nephritis (*Related to decreased renal excretion; accumulation in blood*)
- Pernicious anemias (PA) (*Achlorhydria associated with PA prevents absorption of dietary iron and it accumulates in the blood*)
- Sideroblastic anemias (*Enzyme disorder prevents iron from being incorporated into Hgb and it accumulates in the blood*)
- Thalassemia (*Treatment for some types of thalassemia include blood transfusions, which can lead to iron overload*)
- Transfusions (repeated)
- Vitamin B₆ deficiency (*This vitamin is essential to Hgb formation; deficiency prevents iron from being incorporated into Hgb and it accumulates in the blood*)

Decreased in:

- Acute and chronic infection (*Iron is a nutrient for invading organisms*)
- Carcinoma (*Related to depletion of iron stores*)
- Chronic blood loss (gastrointestinal, uterine) (*Blood contains iron incorporated in Hgb*)
- Hypothyroidism (*Pathophysiology is unclear*)
- Iron-deficiency anemia (*Related to depletion of iron stores*)
- Nephrosis (*Anemia is common in people with kidney disease; fewer RBCs are made due to a deficiency of erythropoietin related to the damaged kidneys, blood can be lost in dialysis, and iron intake may be lower due to lack of appetite*)
- Postoperative state
- Protein malnutrition (kwashiorkor) (*Protein is required to form transport proteins, RBCs, and Hgb*)

CRITICAL VALUES:

Mild toxicity: greater than 350 mcg/dL

Serious toxicity: greater than 400 mcg/dL

Lethal: greater than 1000 mcg/dL

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms. Intervention may include chelation therapy by administration of deferoxamine mesylate (Desferal).

INTERFERING FACTORS:

- Drugs that may increase iron levels include blood transfusions, chemotherapy drugs, iron (intramuscular), iron dextran, iron-protein-succinylate, methimazole, methotrexate, oral contraceptives, and rifampin.
- Drugs that may decrease iron levels include acetylsalicylic acid, allopurinol, cholestyramine, corticotropin, cortisone, deferoxamine, and metformin.
- Gross hemolysis can interfere with test results.
- Failure to withhold iron-containing medications 24 hr before the test may falsely increase values.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used in the differential diagnosis of anemia.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal and hematopoietic systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent therapies that can interfere with test results. Specimen collection should be delayed for several days after blood transfusion.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to fast for at least 12 hr before testing, and with medical direction, to refrain from taking iron-containing medicines before specimen collection. Protocols may vary from facility to facility.
- ▶ There are no fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions; assure that food has been restricted for at least 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, or activity, as directed by the HCP.
- ▶ **Nutritional considerations:** Educate the patient with abnormally elevated iron values, as appropriate, on the importance of reading food labels. Foods high in iron include meats (especially liver), eggs, grains, and green leafy vegetables. It is also important to explain that iron levels in foods can be increased if foods are cooked in cookware containing iron.
- ▶ **Nutritional considerations:** Educate the patient with abnormal iron values that numerous factors affect the absorption of iron, enhancing or decreasing absorption regardless of the original content of the iron-containing dietary source. Patients must be educated to either increase or avoid intake of iron and iron-rich foods depending on their specific condition; for example a patient with hemochromatosis or acute pernicious anemia should be educated to avoid foods rich in iron. Consumption of large amounts of alcohol damages the intestine and allows increased absorption of iron. A high intake of calcium and ascorbic acid also increases iron absorption. Iron absorption after a meal is also increased by factors in meat, fish, and poultry. Iron absorption is decreased by the absence (gastric resection) or diminished presence (use of antacids)

of gastric acid. Phytic acids from cereals, tannins from tea and coffee, oxalic acid from vegetables, and minerals such as copper, zinc, and manganese interfere with iron absorption.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in

relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, biopsy liver, complete blood count, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology, complete blood count, WBC count and differential, erythropoietin, ferritin, folate, FEP, gallium scan, hemosiderin, iron binding/transferrin, lead, porphyrins, reticulocyte count, and vitamin B₁₂.
- ▶ Refer to the Gastrointestinal and Hematopoietic System tables at the back of the book for related tests by body system.

Iron-Binding Capacity (Total), Transferrin, and Iron Saturation

SYNONYM/ACRONYM: TIBC, Fe Sat.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Spectrophotometry for TIBC and nephelometry for transferrin)

Test	Conventional Units	SI Units
TIBC	250–350 mcg/dL	$(\text{Conventional Units} \times 0.179)$ 45–63 micromol/L
Transferrin	200–380 mg/dL	$(\text{Conventional Units} \times 0.01)$ 2–3.8 g/L
Iron saturation	20–50%	

TIBC = total iron-binding capacity.

DESCRIPTION: Iron plays a principal role in erythropoiesis. It is necessary for proliferation and maturation of red blood cells and for hemoglobin (Hgb) synthesis. Of the body's normal 4 g of iron (less in women),

about 65% is present in Hgb and about 3% in myoglobin. A small amount is also found in cellular enzymes that catalyze the oxidation and reduction of iron. The remainder of iron is stored in the liver, bone marrow, and spleen

as ferritin or hemosiderin. Any iron present in the serum is in transit among the alimentary tract, the bone marrow, and available iron storage forms. Iron travels in the bloodstream bound to transport proteins. Transferrin is the major iron-transport protein, carrying 60% to 70% of the body's iron. For this reason, total iron-binding capacity (TIBC) and transferrin are sometimes referred to interchangeably, even though other proteins carry iron and contribute to the TIBC. Unbound iron is highly toxic, but there is generally an excess of transferrin available to prevent the buildup of unbound iron in the circulation. The percentage of iron saturation is calculated by dividing the serum iron value by the TIBC value and multiplying by 100.

INDICATIONS:

- Assist in the diagnosis of iron-deficiency anemia
- Differentiate between iron-deficiency anemia and anemia secondary to chronic disease
- Monitor hematological response to therapy during pregnancy and iron-deficiency anemias
- Provide support for diagnosis of hemochromatosis or diseases of iron metabolism and storage

RESULT:

Increased in:

- Acute liver disease
- Hypochromic (iron-deficiency) anemias (***Insufficient circulating iron levels to saturate binding sites***)
- Late pregnancy

Decreased in:

- Chronic infections (***Transferrin is a negative acute phase reactant***)

protein and during periods of inflammation will demonstrate decreased levels)

- Cirrhosis (***Transferrin is a negative acute phase reactant protein and during periods of inflammation will demonstrate decreased levels)***)
- Hemochromatosis (***Occurs early in the disease as intestinal absorption of iron available for binding increases)***)
- Hemolytic anemias (***Transferrin becomes saturated and the iron-binding capacity is significantly decreased)***)
- Neoplastic diseases (***Transferrin is a negative acute phase reactant protein and during periods of inflammation will demonstrate decreased levels)***)
- Protein depletion (***Transferrin contributes to the total protein concentration and will reflect a decrease in protein depletion)***)
- Renal disease (***Transferrin is a negative acute phase reactant protein and during periods of inflammation will demonstrate decreased levels)***)
- Sideroblastic anemias (***Transferrin becomes saturated and the iron-binding capacity is significantly decreased)***)
- Thalassemia (***Transferrin becomes saturated and the iron-binding capacity is significantly decreased)***)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase TIBC levels include mestranol and oral contraceptives.
- Drugs that may decrease TIBC levels include asparaginase, chloramphenicol, corticotropin, cortisone, and testosterone.

**NURSING IMPLICATIONS
AND PROCEDURE****PRETEST:**

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used in the differential diagnosis of anemia.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include biopsy bone marrow, biopsy liver, complete blood count, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology, complete blood count, WBC count and differential, erythropoietin, ferritin, folate, FEP, gallium scan, hemosiderin, lead, porphyrins, reticulocyte count, and vitamin B₁₂.
- ◆ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Ketones, Blood and Urine

SYNONYM/ACRONYM: Synonyms/acronym: Ketone bodies, acetoacetate, acetone.

SPECIMEN: Serum (1 mL) collected from red- or tiger-top tube. Urine (5 mL), random or timed specimen, collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Colorimetric nitroprusside reaction) Negative.

DESCRIPTION: Ketone bodies refer to the three intermediate products of metabolism: acetone, acetoacetic acid, and β -hydroxybutyrate. Even though β -hydroxybutyrate is not a ketone, it is usually listed with the ketone bodies. In healthy individuals, ketones are produced and completely metabolized by the liver so that measurable amounts are not normally present in serum. Ketones appear in the urine before a significant serum level is detectable. If the patient has excessive fat metabolism, ketones are found in blood and urine. Excessive fat metabolism may occur if the patient has impaired ability to metabolize carbohydrates, inadequate carbohydrate intake, inadequate insulin levels, excessive carbohydrate loss, or increased carbohydrate demand. A strongly positive acetone result without severe acidosis, accompanied by normal glucose, electrolyte, and bicarbonate levels, is strongly suggestive of isopropyl alcohol poisoning. A low-carbohydrate or high-fat diet may cause a positive acetone test. Ketosis in diabetics is usually accompanied by increased glucose and decreased bicarbonate and pH. Extremely elevated levels of ketone bodies can result in coma. This situation is particularly life-threatening in children younger than 10 y.o.

INDICATIONS:

- Assist in the diagnosis of starvation, stress, alcoholism, suspected isopropyl alcohol ingestion, glycogen storage disease, and other metabolic disorders
- Detect and monitor treatment of diabetic ketoacidosis
- Monitor the control of diabetes
- Screen for ketonuria due to acute illness or stress in nondiabetic patients
- Screen for ketonuria to assist in the assessment of inborn errors of metabolism
- Screen for ketonuria to assist in the diagnosis of suspected isopropyl alcohol poisoning

RESULT:

Increased in:

Ketones are generated in conditions that involve the metabolism of carbohydrates, fatty acids, and protein.

- Acidosis
- Branched-chain ketonuria
- Carbohydrate deficiency
- Eclampsia
- Fasting or starvation
- Gestational diabetes
- Glycogen storage diseases
- High-fat or high-protein diet
- Hyperglycemia
- Ketoacidosis of alcoholism and diabetes
- Illnesses with marked vomiting and diarrhea
- Isopropyl alcohol ingestion
- Methylmalonic aciduria
- Postanesthesia period
- Propionyl coenzyme A carboxylase deficiency

Decreased in: N/A

CRITICAL VALUES: 

Strongly positive test results for glucose and ketones

Note and immediately report to the health care provider (HCP) strongly positive results in urine and related symptoms. An elevated level of ketone bodies is evidenced by fruity-smelling breathe, acidosis, ketonuria, and decreased level of consciousness. Administration of insulin and frequent blood glucose measurement may be indicated.

INTERFERING FACTORS:

- Drugs that may cause an increase in serum ketone levels include acetylsalicylic acid (if therapy results in acidosis, especially in children), albuterol, fenfluramine, levodopa, nifedipine, and paraldehyde.
- Drugs that may cause a decrease in serum ketone levels include acetylsalicylic acid and valproic acid. Increases have been shown in hyperthyroid patients receiving propranolol and propylthiouracil.
- Drugs that may increase urine ketone levels include acetylsalicylic acid (if therapy results in acidosis, especially in children), captopril, dimercaprol, ether, ifosfamide, insulin, levodopa, mesna, metformin, methyl dopa, *N*-acetylcysteine, niacin, paraldehyde, penicillamine, phenazopyridine, phenolphthalein, phenolsulfonphthalein, pyrazinamide, streptozocin, sulfobromophthalein, and valproic acid.
- Drugs that may decrease urine ketone levels include acetylsalicylic acid and phenazopyridine.
- Urine should be checked within 60 min of collection.
- Bacterial contamination of urine can cause false-negative results.
- Failure to keep reagent strip container tightly closed can cause false-negative results. Light and

moisture affect the ability of the chemicals in the strip to perform as expected.

- False-negative or weakly false-positive test results can be obtained when β -hydroxybutyrate is the predominating ketone body in cases of lactic acidosis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is most commonly used to investigate diabetes as the cause of ketoacidosis.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that blood specimen collection takes approximately 5 to 10 min. The amount of time required to collect a urine specimen depends on the level of cooperation from the patient. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ Observe standard precautions, and follow the general guidelines in Appendix A.

Blood:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. Alternatively, a finger- or heel-stick method of specimen collection can be used.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

Urine:

- ▶ Review the procedure with the patient. Explain to the patient how to collect a second-voided midstream (1) void, then drink a glass of water; and (2) wait 30 min, and then try to void again.
- ▶ Instruct the patient to avoid excessive exercise and stress before specimen collection.

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Blood or Urine:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Increased levels of ketone bodies may be associated with diabetes. The nutritional needs of each diabetic patient need to be determined individually (especially during pregnancy) by a health care professional trained in nutrition. Patients who adhere to dietary recommendations report a better general feeling of health, better weight

management, greater control of glucose and lipid values, and improved use of insulin. There is no “diabetic diet”; however, many meal-planning approaches with nutritional goals are endorsed by the American Dietetic Association.

- ▶ Impaired glucose tolerance may be associated with diabetes. Instruct the patient and caregiver to report signs and symptoms of hypoglycemia (weakness, confusion, diaphoresis, rapid pulse) or hyperglycemia (thirst, polyuria, hunger, lethargy).
- ▶ **Nutritional considerations:** Increased levels of ketone bodies may be associated with poor carbohydrate intake; therefore, the body breaks down fat instead of carbohydrate for energy. Increasing carbohydrate intake in the patient’s diet reduces the levels of ketone bodies. Carbohydrates can be found in starches and sugars. Starch is a complex carbohydrate that can be found in foods such as grains (breads, cereals, pasta, rice) and starchy vegetables (corn, peas, potatoes). Sugar is a simple carbohydrate that can be found in natural foods (fruits and natural honey) and processed foods (desserts and candy).
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient’s lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Emphasize, as appropriate, that good glycemic control delays the onset of and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Diabetes Association (www.diabetes.org).
- ▶ Reinforce information given by the patient’s HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

♦ Related tests include ACTH, angiography adrenal, anion gap, blood gases, BUN, calcium, catecholamines, cholesterol (HDL, LDL, total), cortisol,

C-peptide, DHEA, electrolytes, fecal analysis, fecal fat, fructosamine, gastric emptying scan, GTT, glycated hemoglobin, HVA, insulin, insulin antibodies, lactic acid, lipoprotein electrophoresis, metanephrines, microalbumin, osmolality, phosphorus, and UA.

♦ Refer to the Endocrine System table at the back of the book for related tests by body system.

Kidney, Ureter, and Bladder Study

SYNONYM/ACRONYM: Flat plate of the abdomen, plain film of the abdomen, scout film, KUB.

AREA OF APPLICATION: Kidneys, ureters, bladder, and abdomen.

CONTRAST: None.

DESCRIPTION: A kidney, ureter, and bladder (KUB) x-ray examination provides information regarding the structure, size, and position of the abdominal organs; it also indicates whether there is any obstruction or abnormality of the abdomen caused by disease or congenital malformation. Calcifications of the renal calyces, renal pelvis, and any radiopaque calculi present in the urinary tract or surrounding organs may be visualized. Normal air and gas patterns are visualized within the intestinal tract. Perforation of the intestinal tract or an intestinal obstruction can be visualized on erect KUB images. KUB x-rays are among the first examinations done to diagnose intra-abdominal diseases such as intestinal obstruction, masses, tumors, ruptured organs, abnormal gas accumulation, and ascites.

INDICATIONS:

- Determine the cause of acute abdominal pain or palpable mass
- Evaluate the effects of lower abdominal trauma, such as internal hemorrhage
- Evaluate known or suspected intestinal obstructions
- Evaluate the presence of renal, ureter, or other organ calculi
- Evaluate the size, shape, and position of the liver, kidneys, and spleen
- Evaluate suspected abnormal fluid, air, or metallic objects in the abdomen

RESULT:

Normal findings in:

- Normal size and shape of kidneys
- Normal bladder, absence of masses and renal calculi, and no abnormal accumulation of air or fluid

Abnormal findings in:

- Abnormal accumulation of bowel gas
- Ascites
- Bladder distention
- Congenital renal anomaly
- Hydronephrosis
- Intestinal obstruction
- Organomegaly
- Renal calculi
- Renal hematomas
- Ruptured viscus
- Soft-tissue masses
- Trauma to liver, spleen, kidneys, and bladder
- Vascular calcification

CRITICAL VALUES:

- Bowel obstruction
- Ischemic bowel
- Visceral injury

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Improper adjustment of the radiographic equipment to accommodate obese or thin patients, which can cause overexposure or underexposure and a poor-quality study
- Incorrect positioning of the patient, which may produce poor visualization of the area to be

examined, for images done by portable equipment

- Retained barium from a previous radiological procedure

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding patients younger than 17.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel remaining in the room with the patient should wear a protective lead apron. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the status of the abdomen.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies and sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that little to no pain is expected during the test, but there may be moments of discomfort. Inform the patient that the procedure is performed in the radiology department or at the bedside by a registered radiologic technologist, and takes approximately 5 to 15 min to complete.

- ◆ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ Instruct the patient to remove all metallic objects from the area to be examined.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ Ensure the patient has removed all metallic objects from the area to be examined, prior to the procedure.
- ◆ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ◆ Instruct the patient to cooperate fully and follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ◆ Place the patient on the table in a supine position with hands relaxed at the side.
- ◆ Instruct the patient to inhale deeply and hold his or her breathe while the x-ray images are taken, and then to exhale after the images are taken.

- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.

POST-TEST:

- ◆ A report will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include angiography renal, calculus kidney stone panel, CT abdomen, CT pelvis, CT renal, IVP, and MRI abdomen, retrograde ureteropyelography, US abdomen, US kidney, US pelvis, and UA.
- ◆ Refer to the Gastrointestinal and Genitourinary System tables at the back of the book for related tests by body system.

Kleihauer-Betke Test

SYNONYM/ACRONYM: Fetal hemoglobin, hemoglobin F, acid elution slide test.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube. Freshly prepared blood smears are also acceptable. Cord blood may be requested for use as a positive control.

REFERENCE VALUE: (Method: Microscopic examination of treated and stained peripheral blood smear) Less than 1%.

DESCRIPTION: The Kleihauer-Betke test is used to determine the degree of fetal-maternal hemorrhage (FMH) and to help calculate the dosage of Rh immune globulin (RhIG); Rh₀(D) RhoGAM[®] IM or Rhophylac IM or IV to be given in some cases of Rh-negative mothers. A sample of maternal blood should be collected within one hour of delivery. A blood film of maternal red blood cells (RBCs) is prepared, treated with an acid buffer, and stained. The acid solution causes hemoglobin to be leached from the maternal cells, giving them a ghost-like appearance. Fetal cells containing hemoglobin F retain their hemoglobin and are stained bright red. Approximately 2000 cells are examined microscopically and counted. The ratio between maternal cells and fetal cells is determined. A percentage of fetal cells is reported. Enumeration of a total of 2000 cells is important to achieve the accuracy and precision to detect a FMH of 15 mL of fetal RBCs or 30 mL of fetal whole blood; the amount of FMH that corresponds to a 300-mcg dose of RhIG. Recommendations for initial RhIG doses range from 100–300 mcg to cover 10–30 mL fetal blood volumes. Many manufacturers recommend additional 50 mcg doses for each 2.5 mL of fetal blood. Calculation of RhIG dosage is based on the calculated size of FMH and *should only be done after reviewing the information in the manufacturer's package insert*. The formula to calculate quantity of fetal bleed in mL of fetal blood is to multiply the percentage of fetal cells in maternal circulation by

50, based on the assumption that maternal blood volume is 5 liters. For example if percentage of fetal cells counted is 0.6%; then $FMH = (0.6 \times 50) = 30$ mL. The formula to calculate FMH in relation to fetal blood cell volume is to multiply the percentage of fetal cells in maternal circulation by 2, based on the assumption that the hematocrit of fetal whole blood is 50%. For example if the quantity of fetal bleed is 30 mL of fetal whole blood; then $FMH = (30/2) = 15$ mL fetal RBCs. Postpartum RhIG should be given within 72 hr of delivery. The test can also be used to distinguish some forms of thalassemia from the hereditary persistence of fetal hemoglobin, but hemoglobin electrophoresis and flow cytometry methods are more commonly used for this purpose.

INDICATIONS:

- Assist in the diagnosis of certain types of anemia
- Calculating dosage of RhoGAM[®]
- Determine whether FMH was a potential cause of death in stillborn delivery
- Screening postpartum maternal blood for the presence of FMH

RESULT:

Positive findings in:

- FMH (*Related to leakage of fetal RBCs into maternal circulation*)
- Hereditary persistence of fetal hemoglobin (*The test does not differentiate fetal hemoglobin from neonate vs adult*)

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Specimens must be obtained before transfusion.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to determine occurrence and extent of fetal-maternal bleed. It is also used to calculate Rh immune globulin dosage.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. Sample must be less than 6 hr old.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amniotic fluid analysis, blood group and type, hemoglobin electrophoresis, and US obstetric.
- ▶ Refer to the Hematopoietic and Reproductive System tables at the back of the book for related tests by body system.

Lactate Dehydrogenase and Isoenzymes

SYNONYM/ACRONYM: LDH and isos, LD and isos.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Enzymatic [L to P] for lactate dehydrogenase, electrophoretic analysis for isoenzymes) Reference ranges are method dependent and may vary from laboratory to laboratory.

Lactate Dehydrogenase

Age	Conventional & SI Units
0–2 yr	125–275 units/L
2–3 yr	166–232 units/L
4–6 yr	104–206 units/L
7–12 yr	90–203 units/L
13–14 yr	90–199 units/L
15–43 yr	90–156 units/L
Greater than 43 yr	90–176 units/L

LDH Fraction	% of Total	Fraction of Total
LDH ₁	14–26	0.14–0.26
LDH ₂	29–39	0.29–0.39
LDH ₃	20–26	0.20–0.26
LDH ₄	8–16	0.08–0.16
LDH ₅	6–16	0.06–0.16

RESULT:

Total LDH increased in:

LDH is released from any damaged cell in which it is stored so conditions that affect the heart, liver, kidneys, red blood cells, skeletal muscle, or other tissue source and cause cellular destruction demonstrate elevated LDH levels.

- Carcinoma of the liver
- Chronic alcoholism
- Cirrhosis
- Congestive heart failure
- Hemolytic anemias
- Hypoxia
- Leukemias
- Megaloblastic and pernicious anemia

- MI or pulmonary infarction
- Musculoskeletal disease
- Obstructive jaundice
- Pancreatitis
- Renal disease (severe)
- Shock
- Viral hepatitis

Total LDH decreased in: N/A

LDH Isoenzymes:

- LDH₁ fraction increased over LDH₂ can be seen in acute MI, anemias (pernicious, hemolytic, acute sickle cell, megaloblastic, hemolytic), and acute renal cortical injury due to any cause. The LDH₁ fraction in particular is elevated in cases of germ cell tumors.

- Increases in the middle fractions are associated with conditions in which massive platelet destruction has occurred (e.g., pulmonary embolism, post-transfusion period), and in lymphatic system disorders (e.g., infectious mononucleosis, lymphomas, lymphocytic leukemias).
- An increase in LDH₅ occurs with musculoskeletal damage and many types of liver damage (e.g., cirrhosis, cancer, hepatitis).

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Lactic Acid

SYNONYM/ACRONYM: Lactate.

SPECIMEN: Plasma (1 mL) collected in a gray-top (sodium fluoride) or green-top (lithium heparin) tube. Specimen should be transported tightly capped and in an ice slurry.

REFERENCE VALUE: (Method: Spectrophotometry/enzymatic analysis)

Conventional Units	SI Units (Conventional Units × 0.111)
3–23 mg/dL	0.3–2.6 mmol/L

DESCRIPTION: Lactic acid (present in blood as lactate) is a by-product of carbohydrate metabolism. Normally metabolized in the liver, lactate concentration is based on the rate of production and metabolism. Levels increase during strenuous exercise, which results in insufficient oxygen delivery to the tissues. Pyruvate, the normal end product of glucose metabolism, is converted to lactate in emergency situations when energy is needed but there is insufficient oxygen in the system to favor the aerobic and customary energy cycle. When

hypoxia or circulatory collapse increases production of lactate, or when the hepatic system does not metabolize lactate sufficiently, lactate levels become elevated. The lactic acid test can be performed in conjunction with pyruvic acid testing to monitor tissue oxygenation. Lactic acidosis can be differentiated from ketoacidosis by the absence of ketosis and grossly elevated glucose levels.

INDICATIONS:

- Assess tissue oxygenation
- Evaluate acidosis

RESULT:**Increased in:**

The liver is the major organ responsible for the breakdown of lactic acid. Any condition affecting normal liver function may also reflect increased blood levels of lactic acid.

- Cardiac failure (*Decreased blood flow and insufficient oxygen in tissues result in accumulation of lactic acid from anaerobic glycolysis*)
- Diabetes (*Inefficient aerobic glycolysis and decreased blood flow caused by diabetes result in accumulation of lactic acid from anaerobic glycolysis*)
- Hemorrhage (*Decreased blood circulation and insufficient oxygen in tissues result in accumulation of lactic acid from anaerobic glycolysis*)
- Hepatic coma (*Related to liver damage and decreased tissue oxygenation*)
- Ingestion of large doses of alcohol or acetaminophen (*Related to liver damage*)
- Lactic acidosis (*Related to strenuous exercise that results in accumulations in metabolic by-products of anaerobic breakdown of sugars for energy*)
- Pulmonary embolism (*Decreased blood flow and insufficient oxygen in tissues result in accumulation of lactic acid from anaerobic glycolysis*)
- Pulmonary failure (*Decreased blood flow and insufficient oxygen in tissues result in accumulation of lactic acid from anaerobic glycolysis*)
- Reye's syndrome (*Related to liver damage*)
- Shock (*Decreased blood flow and insufficient oxygen in tissues result in accumulation of lactic acid from anaerobic glycolysis*)
- Strenuous exercise (*Related to lactic acidosis*)

Decreased in: N/A

CRITICAL VALUES: **Greater than or equal to 31 mg/dL**

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms. Observe the patient for signs and symptoms of elevated levels of lactate, such as Kussmaul's breathing and increased pulse rate. In general, there is an inverse relationship between critically elevated lactate levels and survival.

INTERFERING FACTORS:

- Drugs that may increase lactate levels include albuterol, anticonvulsants (long-term use), epinephrine, IV glucose, isoniazid, lactose, metformin (Glucophage), oral contraceptives, sodium bicarbonate, and sorbitol.
- Falsely low lactate levels are obtained in samples with elevated levels of the enzyme lactate dehydrogenase because this enzyme reacts with the available lactate substrate.
- Using a tourniquet or instructing the patient to clench his or her fist during a venipuncture can cause elevated levels.
- Engaging in strenuous physical activity (i.e., activity in which blood flow and oxygen distribution cannot keep pace with increased energy needs) before specimen collection can cause an elevated result.
- Delay in transport of the specimen to the laboratory must be avoided. Specimens not processed by centrifugation in a tightly stoppered collection container within 15 min of collection should be rejected for analysis. It is preferable to transport specimens to the laboratory in an ice slurry to further retard cellular metabolism that might

shift lactate levels in the sample before analysis.

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to investigate suspected lactic acidosis, most commonly caused by hypoperfusion.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, endocrine, hepatobiliary, musculoskeletal, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Instruct the patient to rest for 1 hr before specimen collection. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ Instruct the patient to fast and to restrict fluids overnight. Instruct the patient not to ingest alcohol for 12 hr before the test. Protocols may vary from facility to facility.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no medication restrictions, unless by medical direction.
- ▶ Prepare an ice slurry in a cup or plastic bag to have on hand for immediate transport of the specimen to the laboratory.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions and other pretesting preparations; assure that food and liquids have been restricted for at least 12 hours prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Instruct the patient *not* to clench and unclench fist immediately before or during specimen collection. Do not use a tourniquet. Perform a venipuncture. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and fluids, as directed by the HCP.
- ▶ **Nutritional considerations:** Instruct patients to consume water when exercising. Dehydration may occur when the body loses water during exercise. Early signs of dehydration include dry mouth, thirst, and concentrated dark yellow urine. If replacement fluids are not consumed at this time, the patient may become moderately dehydrated and exhibit symptoms of extreme thirst, dry oral mucus membranes,

inability to produce tears, decreased urinary output, and light-headedness. Severe dehydration manifests as confusion, lethargy, vertigo, tachycardia, anuria, diaphoresis, and loss of consciousness.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change

in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related laboratory tests include ALT, alveolar/arterial oxygen ratio, ammonia, analgesic and antipyretic drugs, anion gap, AST, biopsy liver, blood gases, CK, glucose, ketones, plethysmography, potassium, pulse oximetry, and sodium.
- ▶ Refer to the Cardiovascular, Endocrine, Hepatobiliary, Musculoskeletal, and Respiratory System tables at the back of the book for related tests by body system.

Lactose Tolerance Test

SYNONYM/ACRONYM: LTT.

SPECIMEN: Plasma (1 mL) collected in gray-top (fluoride/oxalate) tube.

REFERENCE VALUE: (Method: Spectrophotometry)

Change in Glucose Value	Conventional Units	SI Units (Conventional Units × 0.0555)
Normal*	Greater than 30 mg/dL	Greater than 1.7 mmol/L
Inconclusive*	20–30 mg/dL	1.1–1.7 mmol/L
Abnormal*	Less than 20 mg/dL	Less than 1.1 mmol/L

*Compared to fasting sample.

DESCRIPTION: Lactose is a disaccharide found in dairy products. When ingested, lactose is broken down in the intestine, by the sugar-splitting enzyme lactase, into glucose and galactose. When sufficient lactase is not available, intestinal bacteria metabolize the lactose, resulting in abdominal bloating, pain, flatus, and diarrhea. The lactose tolerance test screens for lactose intolerance by

monitoring glucose levels after ingestion of a dose of lactose.

INDICATIONS:

Evaluate patients for suspected lactose intolerance

RESULT:

Glucose levels increased in:

Normal response

Glucose levels decreased in:

Lactose intolerance (Lactase is insufficient to break down ingested lactose into glucose)

CRITICAL VALUES:

Less than 40 mg/dL

Greater than 400 mg/dL

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and symptoms.

Symptoms of decreased glucose levels include headache, confusion, hunger, irritability, nervousness, restlessness, sweating, and weakness. Possible interventions include oral or IV administration of glucose, IV or intramuscular injection of glucagon, and continuous glucose monitoring.

Symptoms of elevated glucose levels include abdominal pain, fatigue, muscle cramps, nausea, vomiting, polyuria, and thirst. Possible interventions include subcutaneous or IV injection of insulin with continuous glucose monitoring.

INTERFERING FACTORS:

- Numerous medications may alter glucose levels (see monograph titled “Glucose”).
- Delayed gastric emptying may decrease glucose levels.
- Smoking may falsely increase glucose levels.
- Failure to follow dietary and activity restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to evaluate lactose intolerance and other malabsorption disorders.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Obtain the pediatric patient's weight to calculate dose of lactose to be administered. Inform the patient that multiple samples will be collected over a 90-min interval. Inform the patient that each specimen collection takes approximately 5 to 10 min. Address concerns about pain related to the procedure. Inform the patient that the test may produce symptoms such as cramps and diarrhea. Instruct the patient not to smoke cigarettes or chew gum during the test. Explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Inform the patient that fasting for at least 12 hr before the test is required and that strenuous activity should also be avoided for at least 12 hr before the test. Protocols may vary from facility to facility.
- ▶ There are no medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and activity restrictions as well as other pretesting preparations; assure that food has been restricted for at least 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Administer 50 g of lactose dissolved in a small amount of water to adults over a 5- to 10-min period. Pediatric

dosage is based on weight: 0.6 to 1.3 g lactose per kilogram of body weight for infants less than 12 mo old; 1.7 g lactose per kilogram of body weight for children 1 to 12 y.o. Record time of ingestion. Encourage the patient to drink one to two glasses of water.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in the appropriate tube or in a red pediatric Microtainer. Samples should be collected at baseline, 30, 45, 60, and 90 min. Record any symptoms the patient reports throughout the course of the test.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. Glucose values change rapidly in an unprocessed, unprocessed specimen; therefore, if a Microtainer is used, each sample should be transported immediately after collection.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient that resuming his or her usual diet may not be possible if lactose intolerance is identified. Educate patients on the importance of following the dietary advice of a

nutritionist to ensure proper nutritional balance.

- ▶ **Nutritional considerations:** Instruct the patient with lactose intolerance to avoid milk products and to carefully read labels on prepared products. Yogurt, which contains inactive lactase enzyme, may be ingested. The lactase in yogurt is activated by the temperature and pH of the duodenum and substitutes for the lack of endogenous lactase. Advise the patient that products such as Lactaid tablets or drops may allow ingestion of milk products without sequelae. Many lactose-free food products are now available in grocery stores.
- ▶ Recognize anxiety related to test results, and be supportive of concerns related to a perceived change in lifestyle. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include D-xylose absorption, fecal analysis, and glucose.
- ▶ Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Laparoscopy, Abdominal

SYNONYM/ACRONYM: Abdominal peritoneoscopy.

AREA OF APPLICATION: Pelvis.

CONTRAST: Carbon dioxide (CO₂).

DESCRIPTION: Abdominal or gastrointestinal (GI) laparoscopy provides direct visualization of the liver, gallbladder, spleen, and stomach after insufflation of carbon dioxide (CO₂). In this procedure, a rigid laparoscope is introduced into the body cavity through a 1- to 2-cm abdominal incision. The endoscope has a microscope to allow visualization of the organs, and it can be used to insert instruments for performing certain procedures, such as biopsy and tumor resection. Under general anesthesia, the peritoneal cavity is inflated with 2 to 3 L of CO₂. The gas distends the abdominal wall so that the instruments can be inserted safely. Advantages of this procedure compared to an open laparotomy include reduced pain, reduced length of stay at the hospital or surgical center, and reduced time off from work.

INDICATIONS:

- Assist in performing surgical procedures such as cholecystectomy, appendectomy, hernia repair, hiatal hernia repair, and bowel resection
- Detect cirrhosis of the liver
- Detect pancreatic disorders
- Evaluate abdominal pain or abdominal mass of unknown origin
- Evaluate abdominal trauma in an emergency

- Evaluate and treat appendicitis
- Evaluate the extent of splenomegaly due to portal hypertension
- Evaluate jaundice of unknown origin
- Obtain biopsy specimens of benign or cancerous tumors
- Stage neoplastic disorders such as lymphomas, Hodgkin's disease, and hepatic carcinoma

RESULT:

Normal findings in:

- Normal appearance of the liver, spleen, gallbladder, pancreas, and other abdominal contents

Abnormal findings in:

- Abdominal adhesions
- Appendicitis
- Ascites
- Cancer of any of the organs
- Cirrhosis of the liver
- Gangrenous gallbladder
- Intra-abdominal bleeding
- Portal hypertension
- Splenomegaly

CRITICAL VALUES:

- Appendicitis

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant,

unless the potential benefits of the procedure far outweigh the risk of radiation exposure to the fetus

- Patients with bleeding disorders, especially those associated with uremia and cytotoxic chemotherapy
- Patients with cardiac conditions or dysrhythmias
- Patients with advanced respiratory or cardiovascular disease
- Patients with intestinal obstruction, abdominal mass, abdominal hernia, or suspected intra-abdominal hemorrhage
- Patients with a history of peritonitis or multiple abdominal operations causing dense adhesions

Factors that may impair clear visualization:

- Gas or feces in the GI tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Patients who are in a hypoxemic or hypercapnic state will require continuous oxygen administration.
- Patients with acute infection or advanced malignancy involving

the abdominal wall are at increased risk because organisms may be introduced into the normally sterile peritoneal cavity.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the abdominal organs.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's GI, genitourinary, reproductive, and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that this procedure is performed before any barium studies.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a surgery department, by a health care provider (HCP), with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is

important in providing psychological support before, during, and after the procedure.

- ◆ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.
- ◆ Inform the patient that a laxative and cleansing enema may be needed the day before the procedure, with cleansing enemas on the morning of the procedure, depending on the institution's policy.
- ◆ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ◆ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ◆ Ensure that the patient has complied with dietary, fluid, and medication restrictions for at least 8 hr prior to the procedure.
- ◆ Ensure the patient has removed all external metallic objects from the area to be examined.
- ◆ Ensure that nonallergy to anesthesia is confirmed before the procedure is performed under general anesthesia.
- ◆ Assess for completion of bowel preparation according to the institution's procedure.
- ◆ Have emergency equipment readily available.
- ◆ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ◆ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ◆ Obtain and record baseline vital signs.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.
- ◆ Insert an IV line or venous access device at a low "keep open" rate.
- ◆ Administer medications, as ordered, to reduce discomfort and to promote relaxation and sedation.

- ◆ Place the patient on the laparoscopy table. If general anesthesia is to be used, it is administered at this time. Place the patient in a modified lithotomy position with the head tilted downward. Cleanse the abdomen with an antiseptic solution, and drape and catheterize the patient, if ordered.
- ◆ The HCP identifies the site for the scope insertion, and administers local anesthesia if that is to be used. After deeper layers are anesthetized, a pneumoperitoneum needle is placed between the visceral and parietal peritoneum.
- ◆ CO₂ is insufflated through the pneumoperitoneum needle to separate the abdominal wall from the viscera and to aid in visualization of the abdominal structures. The pneumoperitoneum needle is removed, and the trocar and laparoscope are inserted through the incision.
- ◆ After the examination, collection of tissue samples, and performance of therapeutic procedures, the scope is withdrawn. All possible CO₂ is evacuated via the trocar, which is then removed. The skin incision is closed with sutures, clips, or sterile strips, and a small dressing or adhesive strip is applied.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual diet, fluids, and medication, as directed by the HCP.
- ◆ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ◆ Instruct the patient to restrict activity for 2 to 7 days after the procedure.
- ◆ If indicated, inform the patient of a follow-up appointment for the removal of sutures.
- ◆ Inform the patient that shoulder discomfort may be experienced for 1 or 2 days after the procedure as a result of abdominal distention caused by

insufflation of CO₂ into the abdomen, and that mild analgesics and cold compresses, as ordered, can be used to relieve the discomfort.

- ▶ Emphasize that any persistent shoulder pain, abdominal pain, vaginal bleeding, fever, redness, or swelling of the incisional area must be reported to the HCP immediately.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed

to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amylase, barium swallow, biopsy bone marrow, complete blood count, complete blood count, WBC count and differential, CT abdomen, CT biliary tract and liver, CT pancreas, CRP, ESR, gallium scan, hepatobiliary scan, KUB, lipase, liver and spleen scan, lymphangiogram, MRI abdomen, MRI pelvis, peritoneal fluid analysis, US abdomen, and US pelvis.
- ▶ Refer to the Gastrointestinal, Genitourinary, Reproductive, and Hepatobiliary System tables in the back of the book for related tests by body system.

Laparoscopy, Gynecologic

L

SYNONYM/ACRONYM: Gynecologic pelviscopy, gynecologic laparoscopy, pelvic endoscopy, peritoneoscopy.

AREA OF APPLICATION: Pelvis.

CONTRAST: Carbon dioxide (CO₂).

DESCRIPTION: Gynecologic laparoscopy provides direct visualization of the internal pelvic contents, including the ovaries, fallopian tubes, and uterus, after insufflation of carbon dioxide (CO₂). It is done to diagnose and treat pelvic organ disorders, as well as to perform surgical procedures on the organs. In this procedure, a rigid laparoscope is introduced into the body cavity through a 1- to 2-cm periumbilical incision. The endoscope has a microscope to allow visualization of the organs, and it can be

used to insert instruments for performing certain procedures, such as biopsy and tumor resection. Under general or local anesthesia, the peritoneal cavity is inflated with 2 to 3 L of CO₂. The gas distends the abdominal wall so that the instruments can be inserted safely. Advantages of this procedure compared to an open laparotomy include reduced pain, reduced length of stay at the hospital or surgical center, and reduced time off from work.

INDICATIONS:

- Detect ectopic pregnancy and determine the need for surgery
- Detect pelvic inflammatory disease or abscess
- Detect uterine fibroids, ovarian cysts, and uterine malformations (ovarian cysts may be aspirated during the procedure)
- Evaluate amenorrhea and infertility
- Evaluate fallopian tubes and anatomic defects to determine the cause of infertility
- Evaluate known or suspected endometriosis, salpingitis, and hydrosalpinx
- Evaluate pelvic pain or masses of unknown cause
- Evaluate reproductive organs after therapy for infertility
- Obtain biopsy specimens to confirm suspected pelvic malignancies or metastasis
- Perform tubal sterilization and ovarian biopsy
- Perform vaginal hysterectomy
- Remove adhesions or foreign bodies such as intrauterine devices
- Treat endometriosis through electrocautery or laser vaporization

RESULT:**Normal findings in:**

- Normal appearance of uterus, ovaries, fallopian tubes, and other pelvic contents

Abnormal findings in:

- Ectopic pregnancy
- Endometriosis
- Ovarian cyst
- Ovarian tumor
- Pelvic adhesions
- Pelvic inflammatory disease
- Pelvic tumor
- Salpingitis
- Uterine fibroids

CRITICAL VALUES:

- Ectopic pregnancy
- Foreign body
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Patients with bleeding disorders, especially those associated with uremia and cytotoxic chemotherapy
- Patients with cardiac conditions or dysrhythmias
- Patients with advanced respiratory or cardiovascular disease
- Patients with intestinal obstruction, abdominal mass, abdominal hernia, or suspected intra-abdominal hemorrhage

Factors that may impair clear visualization:

- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

- Patients who are in a hypoxemic or hypercapnic state will require continuous oxygen administration.
- Patients with acute infection or advanced malignancy involving the abdominal wall are at increased risk because organisms may be introduced into the normally sterile peritoneal cavity

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the abdominal and pelvic organs.
- ▶ Obtain a history of the patient's complaints, including a list of known allergies, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's GI, genitourinary, reproductive, and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that this procedure is performed before any barium studies.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be

moments of discomfort. Inform the patient that the procedure is performed in a surgery department, by a health care provider (HCP) and support staff and takes approximately 30 to 60 minutes.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.
- ▶ Inform the patient that a laxative and cleansing enema may be needed the day before the procedure, with cleansing enemas on the morning of the procedure, depending on the institution's policy.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions for at least 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ Ensure that nonallergy to anesthesia is confirmed before the procedure is performed under general anesthesia.
- ▶ Assess for completion of bowel preparation according to the institution's procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.

- ▶ Obtain and record baseline vital signs.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Insert an IV line or venous access device at a low “keep open” rate.
- ▶ Administer medications, as ordered, to reduce discomfort and to promote relaxation and sedation.
- ▶ Place the patient on the laparoscopy table. If general anesthesia is to be used, it is administered at this time. Place the patient in a modified lithotomy position with the head tilted downward. Cleanse the abdomen with an antiseptic solution, and drape and catheterize the patient, if ordered.
- ▶ The HCP identifies the site for the scope insertion, and administers local anesthesia if that is to be used. After deeper layers are anesthetized, a pneumoperitoneum needle is placed between the visceral and parietal peritoneum.
- ▶ CO₂ is insufflated through the pneumoperitoneum needle to separate the abdominal wall from the viscera and to aid in visualization of the abdominal structures. The pneumoperitoneum needle is removed, and the trocar and laparoscope are inserted through the incision.
- ▶ The HCP inserts a uterine manipulator through the vagina and cervix and into the uterus so that the uterus, fallopian tubes, and ovaries can be moved to permit better visualization.
- ▶ After the examination, collection of tissue samples, and performance of therapeutic procedures (e.g., tubal ligation), the scope is withdrawn. All possible CO₂ is evacuated via the trocar, which is then removed. The skin incision is closed with sutures, clips, or sterile strips, and a small dressing or adhesive strip is applied. After the perineum is cleansed, the uterine manipulator is removed and a sterile pad applied.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
 - ▶ Instruct the patient to resume usual diet, fluids, and medication, as directed by the HCP.
- ▶ Monitor vital signs and neurological status every 15 minutes for 1 hour, then every 2 hr for 4 hr, and as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
 - ▶ Instruct the patient to restrict activity for 2 to 7 days after the procedure.
 - ▶ If indicated, inform the patient of a follow-up appointment for the removal of sutures.
 - ▶ Inform the patient that shoulder discomfort may be experienced for 1 or 2 days after the procedure as a result of abdominal distention caused by insufflation of CO₂ into the abdomen, and that mild analgesics and cold compresses, as ordered, can be used to relieve the discomfort.
 - ▶ Emphasize that any persistent shoulder pain, abdominal pain, vaginal bleeding, fever, redness, or swelling of the incisional area must be reported to the HCP immediately.
 - ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include cancer antigens, *Chlamydia* group antibody, CT abdomen, CT pelvis, HCG, MRI pelvis, PAP smear, progesterone, US pelvis, and uterine fibroid embolization.
- ▶ Refer to the Gastrointestinal, Genitourinary, Reproductive, and Hepatobiliary System tables in the back of the book for related tests by body system.

Latex Allergy

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Immunoassay) Negative.

RESULT: *Negative findings in:* N/A

*Positive findings in:
Latex allergy*

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Lead

SYNONYM/ACRONYM: Pb.

SPECIMEN: Whole blood (1 mL) collected in a special lead-free royal blue- or tan-top tube. Plasma (1 mL) collected in lavender-top (EDTA) tube is also acceptable.

REFERENCE VALUE: (Method: Atomic absorption spectrophotometry)

	Conventional Units	SI Units (Conventional Units × 0.0483)
Children	0–9.9 mcg/dL	0–0.48 micromol/L
Adults	0–25.0 mcg/dL	0–1.20 micromol/L
OSHA action limit for occupational exposure	Up to 40 mcg/dL	Up to 1.93 micromol/L

OSHA = Occupational Safety and Health Administration.

DESCRIPTION: Lead is a heavy metal and trace element. It is absorbed through the respiratory and gastrointestinal systems. It can also be transported from mother to fetus through the

placenta. When there is frequent exposure to lead-containing items (e.g., paint, batteries, gasoline, pottery, bullets, printing materials) or occupations (mining, automobile, printing, and

welding industries), many organs of the body are affected. Lead poisoning can cause severe behavioral and neurological effects. The blood test is considered the best indicator of lead poisoning, and confirmation is made by the lead mobilization test performed on a 24-hr urine specimen.

INDICATIONS:

Assist in the diagnosis and treatment of lead poisoning

RESULT:

Increased in:

Heme synthesis involves the conversion of D-amino levulinic acid to porphobilinogen. Lead interferes with the enzyme that is responsible for this critical step in heme synthesis, amino levulinic acid dehydrase.

- Anemia of lead intoxication
- Lead encephalopathy
- Metal poisoning

Decreased in: N/A

CRITICAL VALUES:

Levels greater than 30 mcg/dL indicate significant exposure.

Levels greater than 60 mcg/dL require chelation therapy.

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms.

INTERFERING FACTORS:

Contamination of the collection site and/or specimen with lead in dust can be avoided by taking special care to have the surfaces surrounding the collection location cleaned. Extra care should also be used to avoid contamination during the actual venipuncture.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to detect lead toxicity and monitor exposure to lead.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a history of the patient's exposure to lead.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ♦ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ♦ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for

bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be

performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include δ -aminolevulinic acid, complete blood count, complete blood count, RBC morphology, erythrocyte protoporphyrin, and urine porphyrins.
- ▶ Refer to the Hematopoietic and Therapeutic/Toxicology tables at the back of the book for related tests by body system.

Lecithin/Sphingomyelin Ratio

SYNONYM/ACRONYM: L/S ratio.

SPECIMEN: Amniotic fluid (10 mL) collected in a sterile, brown glass or plastic tube or bottle protected from light.

REFERENCE VALUE: (Method: Thin-layer chromatography)

Mature (nondiabetic): Greater than 2:1 in the presence of phosphatidyl glycerol

Borderline: 1.5 to 1.9:1

Immature: Less than 1.5:1

DESCRIPTION: Respiratory distress syndrome (RDS) is the most common problem encountered in the care of premature infants. RDS, also called hyaline membrane disease, results from a deficiency of phospholipid lung surfactants. The phospholipids in surfactant are produced by specialized alveolar cells and stored in granular lamellar bodies in the lung. In normally developed lungs, surfactant coats the surface of the alveoli. Surfactant reduces the surface tension of the alveolar wall during breathing. When there is

an insufficient quantity of surfactant, the alveoli are unable to expand normally and gas exchange is inhibited. Amniocentesis, a procedure by which fluid is removed from the amniotic sac, is used to assess fetal lung maturity.

Lecithin is the primary surfactant phospholipid, and it is a stabilizing factor for the alveoli. It is produced at a low but constant rate until the 35th wk of gestation, after which its production sharply increases. Sphingomyelin, another phospholipid component of surfactant, is also produced at

a constant rate after the 26th wk of gestation. Before the 35th wk, the lecithin/sphingomyelin (L/S) ratio is usually less than 1.6:1. The ratio increases to 2.0 or greater when the rate of lecithin production increases after the 35th wk of gestation. Other phospholipids, such as phosphatidyl glycerol (PG) and phosphatidyl inositol (PI), increase over time in amniotic fluid as well. The presence of PG indicates that the fetus is within 2 to 6 wk of lung maturity (i.e., at full term). Simultaneous measurement of PG with the L/S ratio improves diagnostic accuracy. Production of phospholipid surfactant is delayed in diabetic mothers. Therefore, caution must be used when interpreting the results obtained from a diabetic patient, and a higher ratio is expected to predict maturity.

INDICATIONS:

- Assist in the evaluation of fetal lung maturity
- Determine the optimal time for obstetric intervention in cases of threatened fetal survival caused by stresses related to maternal diabetes, toxemia, hemolytic diseases of the newborn, or postmaturity
- Identify fetuses at risk of developing RDS

RESULT:

Increased in:

Conditions that increase production of surfactant

- Hypertension
- Intrauterine growth retardation
- Malnutrition
- Maternal diabetes
- Placenta previa
- Placental infarction
- Premature rupture of the membranes

Decreased in:

Conditions that decrease production of surfactant

- Advanced maternal age
- Immature fetal lungs
- Multiple gestation
- Polyhydramnios

CRITICAL VALUES:

An L/S ratio less than 1.5:1 is predictive of RDS at the time of delivery.

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms. Infants known to be at risk for RDS can be treated with surfactant by intratracheal administration at birth.

INTERFERING FACTORS:

- Fetal blood falsely elevates the L/S ratio.
- Exposing the specimen to light may cause falsely decreased values.
- There is some risk to having an amniocentesis performed, and this should be weighed against the need to obtain the desired diagnostic information. A small percentage (0.5%) of patients have experienced complications including premature rupture of the membranes, premature labor, spontaneous abortion, and stillbirth.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is primarily used to obtain an estimate of fetal lung maturity.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's reproductive and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Include any family history of genetic disorders such as cystic fibrosis, Duchenne's muscular dystrophy, hemophilia, sickle cell disease, Tay-Sachs disease, thalassemia, and trisomy 21. Obtain maternal Rh type. If Rh-negative, check for prior sensitization. A standard RhoGAM dose is indicated after amniocentesis; repeat doses should be considered if repeated amniocentesis is performed.
- ▶ Record the date of the last menstrual period, and determine that the pregnancy is in the third trimester between the 28th and 40th wk.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Warn the patient that normal results do not guarantee a normal fetus. Assure the patient that precautions to avoid injury to the fetus will be taken by localizing the fetus with ultrasound. Address concerns about pain and explain that during the transabdominal procedure, any discomfort with a needle biopsy will be minimized with local anesthetics. Patients who are at 20 wk gestation or beyond should void before the test, because an empty bladder is less likely to be accidentally punctured during specimen collection. Encourage relaxation and controlled breathing during the procedure to aid in reducing any mild discomfort. Inform the patient that specimen collection is performed by a HCP specializing in this procedure and usually takes approximately 20 to 30 min to complete.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*


INTRATEST:

- ▶ Ensure that the patient has voided before the procedure if gestation is 21 wk or more.
- ▶ Have emergency equipment readily available.
- ▶ Have patient remove clothes below the waist. Assist the patient to a supine position on the exam table with abdomen exposed. Drape the patient's legs, leaving the abdomen exposed. Raise her head or legs slightly to promote comfort and to relax abdominal muscles. If the uterus is large, place a pillow or rolled blanket under the patient's right side to prevent hypertension caused by great-vessel compression.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Record maternal and fetal baseline vital signs and continue to monitor throughout the procedure. Monitor for uterine contractions. Monitor fetal vital signs using ultrasound. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Assess the position of the amniotic fluid, fetus, and placenta using ultrasound.
- ▶ Assemble the necessary equipment, including an amniocentesis tray with solution for skin preparation, local anesthetic, 10- or 20-mL syringe, needles of various sizes (including a 22-gauge, 5-in. spinal needle), sterile drapes, sterile gloves, and foil-covered or amber specimen collection containers.
- ▶ Cleanse suprapubic area with an antiseptic solution and protect with sterile drapes. A local anesthetic is injected. Explain that this may cause a stinging sensation.
- ▶ A 22-gauge, 5-in. spinal needle is inserted through the abdominal and

uterine walls. Explain that a sensation of pressure may be experienced when the needle is inserted. Explain to the patient how to use focusing and controlled breathing for relaxation during the procedure.

- ▶ After the fluid is collected and the needle withdrawn, apply slight pressure to the site. Apply a sterile adhesive bandage to the site.
- ▶ Monitor the patient for complications related to the procedure (e.g., premature labor, allergic reaction, anaphylaxis).
- ▶ Place samples in properly labeled specimen container and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶  Fetal heart rate and maternal vital signs (i.e., heart rate, blood pressure, pulse, and respiration) must be compared to baseline values and closely monitored every 15 min for 30 to 60 min after the amniocentesis procedure. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the amniocentesis site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the amniocentesis site. Instruct the patient to report any redness, edema, bleeding, or pain at the site. Instruct the patient to keep the site clean and change the dressing as needed.
- ▶ Instruct the patient to expect mild cramping, leakage of small amount of amniotic fluid, and vaginal spotting for up to 2 days following the procedure. Instruct the patient to immediately report moderate to severe abdominal pain or cramps, change in fetal activity, increased or prolonged leaking of amniotic fluid from abdominal needle site, vaginal bleeding that is heavier than

spotting, and either chills or fever to the HCP.

- ▶ Instruct the patient to rest until all symptoms have disappeared before resuming normal levels of activity.
- ▶ Administer standard dose of Rh₀(D) immune globulin RhoGAM IM or Rhophylac IM or IV to maternal Rh-negative patients to prevent maternal Rh sensitization should the fetus be Rh-positive.
- ▶ Administer mild analgesic and antibiotic therapy as ordered. Remind the patient of the importance of completing the entire course of antibiotic therapy, even if signs and symptoms disappear before completion of therapy.
- ▶ Recognize anxiety related to test results, and offer support. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Encourage the family to seek counseling if concerned with pregnancy termination or to seek genetic counseling if a chromosomal abnormality is determined. Decisions regarding elective abortion should take place in the presence of both parents. Provide a nonjudgmental, nonthreatening atmosphere for discussing the risks and difficulties of delivering and raising a developmentally challenged infant, as well as exploring other options (termination of pregnancy or adoption). It is also important to discuss feelings the mother and father may experience (e.g., guilt, depression, anger) if fetal abnormalities are detected.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor

progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include amniotic fluid analysis, antibodies anticardiolipin,

blood groups and antibodies, chromosome analysis, fetal fibronectin, α -fetoprotein, glucose, ketones, Kleihauer-Betke test, potassium, US obstetric, and UA.

Refer to the Reproductive and Respiratory System tables at the back of the book for related tests by body system.

Leukocyte Alkaline Phosphatase

SYNONYM/ACRONYM: Synonyms/acronym: LAP, LAP score, LAP smear.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Microscopic evaluation of specially stained blood smears) 25 to 130 (score based on 0 to 4+ rating of 100 neutrophils).

DESCRIPTION: Alkaline phosphatase is an enzyme important for intracellular metabolic processes. It is present in the cytoplasm of neutrophilic granulocytes from the metamyelocyte to the segmented stage. Leukocyte alkaline phosphatase (LAP) concentrations may be altered by the presence of infection, stress, chronic inflammatory diseases, Hodgkin's disease, and hematological disorders. Levels are low in leukemic leukocytes and high in normal white blood cells (WBCs), making this test useful as a supportive test in the differential diagnosis of leukemia. It should be noted that test results must be correlated with the patient's condition because LAP levels increase toward normal in response to therapy.

INDICATIONS:

- Differentiate chronic myelocytic leukemia from other disorders that increase the WBC count
- Monitor response of Hodgkin's disease to therapy

RESULT:

Increased in:

Conditions that result in an increase in leukocytes in all stages of maturity will reflect a corresponding increase in LAP.

- Aplastic leukemia
- Chronic inflammation
- Down's syndrome
- Hairy cell leukemia
- Hodgkin's disease
- Leukemia (acute and chronic lymphoblastic)
- Myelofibrosis with myeloid metaplasia
- Multiple myeloma
- Polycythemia vera (**Increase in all blood cell lines, including leukocytes**)
- Pregnancy

- Stress
- Thrombocytopenia

Decreased in:

- Chronic myelogenous leukemia
- Hereditary hypophosphatemia (**Insufficient phosphorus levels**)
- Idiopathic thrombocytopenia purpura
- Nephrotic syndrome (**Excessive loss of phosphorus**)
- Paroxysmal nocturnal hemoglobinuria (**Possibly related to the lack or absence of LAP and other proteins anchored to the red blood cell wall resulting in complement-mediated hemolysis**)
- Sickle cell anemia
- Sideroblastic anemia

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Drugs that may increase the LAP score include steroids.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate disorders of the hematological system.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately

5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to avoid exposure to infection if WBC count is decreased.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, calcium, complete blood count, complete blood count, platelet count, complete blood count, WBC count and differential, CT thoracic, gallium scan, Ham's test, Hgb electrophoresis, hemosiderin, IFE, immunoglobulins, iron, laparoscopy abdominal, liver and spleen scan, lymphangiogram, mediastinoscopy, phosphorus, and sickle cell screen.
- ▶ Refer to the Hematopoietic and Immune System tables at the back of the book for related tests by body system.

Lipase

SYNONYM/ACRONYM: Triacylglycerol acylhydrolase.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Enzymatic Spectrophotometry)

Conventional & SI Units

3–73 units/L

DESCRIPTION: Lipases are digestive enzymes secreted by the pancreas into the duodenum. Different lipolytic enzymes have specific substrates, but overall activity is collectively described as lipase. Lipase participates in fat digestion by breaking down triglycerides into fatty acids and glycerol. Lipase is released into the bloodstream when damage occurs to the pancreatic acinar cells. Its presence in the blood indicates pancreatic disease because the pancreas is the only organ that secretes this enzyme.

INDICATIONS:

- Assist in the diagnosis of acute and chronic pancreatitis
- Assist in the diagnosis of pancreatic carcinoma

RESULT:**Increased in:**

Lipase is contained in pancreatic tissue and is released into the serum when cell damage or necrosis occurs.

- Acute cholecystitis
- Obstruction of the pancreatic duct
- Pancreatic carcinoma (early)
- Pancreatic cyst or pseudocyst
- Pancreatic inflammation
- Pancreatitis (acute and chronic)
- Renal failure (***Lipase is excreted by the kidneys; decreased kidney function will reflect an increase in serum lipase.***)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase lipase levels include asparaginase, azathioprine, cholinergics, codeine, deoxycholate, didanosine, glycocholate, indomethacin, methacholine, methylprednisolone, morphine, narcotics, pancreozymin, pentazocine, and taurocholate.
- Drugs that may decrease lipase levels include protamine and saline (IV infusions).
- Endoscopic retrograde cholangiopancreatography may increase lipase levels.
- Serum lipase levels increase with hemodialysis. Therefore, predialysis specimens should be collected for lipase analysis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to diagnose pancreatitis.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal (GI) and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain

and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Instruct the patient to ingest small, frequent meals if he or she has a GI disorder; advise the patient to consider other dietary alterations as well. After acute symptoms subside and bowel sounds return, patients are usually prescribed a clear liquid diet, progressing to a low-fat, high-carbohydrate diet.
- ▶ Administer vitamin B₁₂, as ordered, to the patient with decreased lipase levels, especially if his or her disease prevents adequate absorption of the vitamin.
- ▶ Encourage the alcoholic patient to avoid alcohol and to seek appropriate counseling for substance abuse.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ALT, ALP, amylase, AST, bilirubin, calcitonin stimulation, calcium, cancer antigens, cholangiography percutaneous transhepatic, cholesterol, complete blood count, ERCP, fecal fat, GGT, hepatobiliary scan, magnesium, MRI pancreas, mumps serology, pleural fluid analysis, peritoneal fluid analysis, triglycerides, US pancreas, and complete blood count, WCB count and diff.
- ◆ Refer to the Gastrointestinal and Hepatobiliary System tables at the back of the book for related tests by body system.

Lipoprotein Electrophoresis

SYNONYM/ACRONYM: Lipid fractionation; lipoprotein phenotyping; 3g_a-lipoprotein cholesterol, high-density lipoprotein (HDL); β-lipoprotein cholesterol, low-density lipoprotein (LDL); pre-β-lipoprotein cholesterol, very-low-density lipoprotein (VLDL).

SPECIMEN: Serum (3 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Electrophoresis and 4°C test for specimen appearance) There is no quantitative interpretation of this test. The specimen appearance and electrophoretic pattern is visually interpreted.

Hyperlipoproteinemia: Fredrickson Type	Specimen Appearance	Electrophoretic Pattern
Type I	Clear with creamy top layer	Heavy chylomicron band
Type IIa	Clear	Heavy β band
Type IIb	Clear or faintly turbid	Heavy β and pre-β bands
Type III	Slightly to moderately turbid	Heavy β band
Type IV	Slightly to moderately turbid	Heavy pre-β band
Type V	Slightly to moderately turbid with creamy top layer	Intense chylomicron band and heavy pre-β band

RESULT:

Type I: Hyperlipoproteinemia or increased chylomicrons can be primary, **resulting from an inherited deficiency of lipoprotein lipase**; or secondary, **caused by**

uncontrolled diabetes, systemic lupus erythematosus, and dysgammaglobulinemia. Total cholesterol is normal to moderately elevated and triglycerides (mostly exogenous chylomicrons) are

grossly elevated. If the condition is inherited, symptoms will appear in childhood.

Type IIa: Hyperlipoproteinemia can be primary, **resulting from inherited characteristics**; or secondary, **caused by uncontrolled hypothyroidism, nephrotic syndrome, and dysgammaglobulinemia**.

Total cholesterol is elevated, triglycerides are normal, and LDL cholesterol (LDLC) is elevated. If the condition is inherited, symptoms will appear in childhood.

Type IIb: Hyperlipoproteinemia **can occur for the same reasons as in type IIa**. Total cholesterol, triglycerides, and LDLC are all elevated.

Type III: Hyperlipoproteinemia can be primary, **resulting from inherited characteristics**; or secondary, **caused by hypothyroidism, uncontrolled diabetes, alcoholism, and dysgammaglobulinemia**. Total cholesterol

and triglycerides are elevated, whereas LDLC is normal.

Type IV: Hyperlipoproteinemia can be primary, **resulting from inherited characteristics**; or secondary, **caused by poorly controlled diabetes, alcoholism, nephrotic syndrome, chronic renal failure, and dysgammaglobulinemia**. Total cholesterol is normal to moderately elevated, triglycerides are moderately to grossly elevated, and LDLC is normal.

Type V: Hyperlipoproteinemia can be primary, **resulting from inherited characteristics**; or secondary, **caused by uncontrolled diabetes, alcoholism, nephrotic syndrome, and dysgammaglobulinemia**. Total cholesterol is normal to moderately elevated, triglycerides are grossly elevated, and LDLC is normal.

CRITICAL VALUES: N/A

Find and print out the full monograph at [DavisPlus \(davisplus.fadavis.com, keyword Van Leeuwen\)](http://DavisPlus(davisplus.fadavis.com, keyword Van Leeuwen).

L

Liver and Spleen Scan

SYNONYM/ACRONYM: Liver and spleen scintigraphy, liver-spleen scan, radionuclide liver scan, spleen scan.

AREA OF APPLICATION: Abdomen.

CONTRAST: IV radioactive technetium-99m sulfur colloid.

DESCRIPTION: The liver and spleen scan is performed to help diagnose abnormalities in the function and structure of the liver and spleen. It is often performed in combination with lung scanning to help diagnose masses or inflammation in the diaphragmatic area. This procedure is useful for evaluating

right-upper-quadrant pain, metastatic disease, jaundice, cirrhosis, ascites, traumatic infarction, and radiation-induced organ cellular necrosis. Technetium-99m (Tc-99m) sulfur colloid is injected IV and rapidly taken up through phagocytosis by the reticuloendothelial cells, which normally function to remove

particulate matter, including radioactive colloids in the liver and spleen. False-negative results may occur in patients with space-occupying lesions (e.g., tumors, cysts, abscesses) smaller than 2 cm. This scan can detect portal hypertension, demonstrated by a greater uptake of the radionuclide in the spleen than in the liver. Single-photon emission computed tomography (SPECT) has significantly improved the resolution and accuracy of liver scanning. SPECT enables images to be recorded from multiple angles around the body and reconstructed by a computer to produce images or “slices” representing the organ at different levels. For evaluation of a suspected hemangioma, the patient’s red blood cells are combined with Tc-99m and images are recorded over the liver. To confirm the diagnosis, liver and spleen scans are done in conjunction with computed tomography (CT), magnetic resonance imaging (MRI), ultrasonography (US), and SPECT scans and interpreted in light of the results of liver function tests.

INDICATIONS:

- Assess the condition of the liver and spleen after abdominal trauma
- Detect a bacterial or amebic abscess
- Detect and differentiate between primary and metastatic tumor focal disease
- Detect benign tumors, such as adenoma and cavernous hemangioma
- Detect cystic focal disease
- Detect diffuse hepatocellular disease, such as hepatitis and cirrhosis
- Detect infiltrative processes that affect the liver, such as sarcoidosis and amyloidosis
- Determine superior vena cava obstruction or Budd-Chiari syndrome
- Differentiate between splenomegaly and hepatomegaly
- Evaluate the effects of lower abdominal trauma, such as internal hemorrhage
- Evaluate jaundice
- Evaluate liver and spleen damage caused by radiation therapy or toxic drug therapy
- Evaluate palpable abdominal masses

RESULT:

Normal findings in:

- Normal size, contour, position, and function of the liver and spleen

Abnormal findings in:

- Abscesses
- Cirrhosis
- Cysts
- Hemangiomas
- Hematomas
- Hepatitis
- Hodgkin’s disease
- Infarction
- Infection
- Infiltrative process (amyloidosis and sarcoidosis)
- Inflammation of the diaphragmatic area
- Metastatic tumors
- Nodular hyperplasia
- Portal hypertension
- Primary benign or malignant tumors
- Traumatic lesions

CRITICAL VALUES:

- Visceral injury

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless

the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Other nuclear scans done within the preceding 24 to 48 hr

Other considerations:

- The scan may fail to detect focal lesions smaller than 2 cm in diameter.
- Improper injection of the radionuclide may allow the tracer to seep deep into the muscle tissue, producing erroneous hot spots.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses liver and spleen function.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's gastrointestinal and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the medications the patient is taking, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in a nuclear medicine department by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no dietary restrictions prior to the procedure.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.

- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in a supine position on a flat table with foam wedges, which help maintain position and immobilization.
- ▶ IV radionuclide is administered and the abdomen is scanned immediately to screen for vascular lesions with images taken in various positions.
- ▶ The patient may be imaged by SPECT techniques to further clarify areas of suspicious radionuclide localization.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Instruct the patient to resume usual medication and activity, as directed by the HCP.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the

radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.

- ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes. High fat consumption increases the amount of bile acids in the colon and should be avoided.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALT, antibodies antimitochondrial, AST, bilirubin, biopsy liver, CT abdomen, CT biliary tract and liver, GGT, HAV, HBV, HCV, hepatobiliary scan, MRI abdomen, and US liver.
- ▶ Refer to the Gastrointestinal and Hepatobiliary System tables at the back of the book for related tests by body system.

Lung Perfusion Scan

SYNONYM/ACRONYM: Radioactive perfusion scan, lung scintiscan, lung perfusion scintigraphy, ventilation-perfusion scan, pulmonary scan, radionuclide perfusion lung scan, V/Q scan.

AREA OF APPLICATION: Chest/thorax.

CONTRAST: IV radioactive material, usually macroaggregated albumin (MAA).

DESCRIPTION: The lung perfusion scan is a nuclear medicine study performed to evaluate a patient for pulmonary embolus (PE) or other pulmonary disorders. Technetium (Tc-99m) is injected IV and distributed throughout the pulmonary vasculature because of the gravitational effect on perfusion. The scan, which produces a visual image of pulmonary blood flow, is useful in diagnosing or confirming pulmonary vascular obstruction. The diameter of the IV injected macroaggregated albumin (MAA) is larger than that of the pulmonary capillaries; therefore, the MAA temporarily becomes lodged in the pulmonary vasculature. A gamma camera detects the radiation emitted from the injected radioactive material, and a representative image of the lung is obtained. This procedure is often done in conjunction with the lung ventilation scan to obtain clinical information that assists in differentiating among the many possible pathological conditions revealed by the procedure. The results are correlated with other diagnostic studies, such as pulmonary function, chest x-ray, pulmonary angiography, and

arterial blood gases. A recent chest x-ray is essential for accurate interpretation of the lung perfusion scan. An area of non-perfusion seen in the same area as a pulmonary parenchymal abnormality on the chest x-ray indicates that a PE is not present; the defect may represent some other pathological condition, such as pneumonia.

INDICATIONS:

- Aid in the diagnosis of PE in a patient with a normal chest x-ray
- Detect malignant tumor
- Differentiate between PE and other pulmonary diseases, such as pneumonia, pulmonary effusion, atelectasis, asthma, bronchitis, emphysema, and tumors
- Evaluate perfusion changes associated with congestive heart failure and pulmonary hypertension
- Evaluate pulmonary function preoperatively in a patient with pulmonary disease

RESULT:

Normal findings in:

- Diffuse and homogeneous uptake of the radioactive material by the lungs

Abnormal findings in:

- Asthma
- Atelectasis
- Bronchitis
- Chronic obstructive pulmonary disease
- Emphysema
- Left atrial or pulmonary hypertension
- Lung displacement by fluid or chest masses
- Pneumonia
- Pneumonitis
- PE
- Tuberculosis

CRITICAL VALUES:

- Pulmonary embolism

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Patients with atrial and ventricular septal defects, because the MAA particles will not reach the lungs
- Patients with pulmonary hypertension

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Other nuclear scans done on the same day

Other considerations:

- Improper injection of the radionuclide may allow the tracer to seep

deep into the muscle tissue, producing erroneous hot spots.

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses blood flow to the lungs.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's respiratory system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that

the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department, by a HCP specializing in this procedure, with support staff, and takes approximately 60 min.

- ◆ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ◆ There are no food, fluid or medication restrictions, unless by medical direction.
- ◆ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ◆ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ◆ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ◆ Have emergency equipment readily available.
- ◆ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ◆ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ◆ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.
- ◆ Administer a sedative to a child or to an uncooperative adult, as ordered.
- ◆ Place the patient in a supine position on a flat table with foam wedges, which help maintain position and immobilization.
- ◆ IV radionuclide is administered and the abdomen is scanned immediately to

screen for vascular lesions with images taken in various positions.

- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ◆ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ◆ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ◆ Monitor vital signs and neurological status every 15 min for one hr, then every 2 hr for 4 hr, and then as ordered by HCP. Compare with baseline values. Protocols may vary from facility to facility.
- ◆ Instruct the patient to resume usual medication and activity, as directed by the HCP.
- ◆ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ◆ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ◆ Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- ◆ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ◆ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after

each voiding for 24 hr after the procedure.

- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include α -1 AT, eosinophil count, ACE, alveolar/arterial gradient, angiography pulmonary, biopsy lung, blood gases, blood pool imaging, bronchoscopy, carbon dioxide, chest x-ray, complete blood count, complete blood count, CT thoracic, complete blood count, WCB count and differential, culture and smear mycobacteria, culture blood, culture throat, culture sputum, culture viral, cytology sputum, ESR, IgE, gallium scan, lung ventilation scan, MRI chest, mediastinoscopy, plethysmography, pleural fluid analysis, PET heart, PFT, pulse oximetry, and TB skin tests.
- ▶ Refer to the Respiratory System table at the back of the book for related tests by body system.

Lung Ventilation Scan

SYNONYM/ACRONYM: Radioactive ventilation scan, VQ lung scan, aerosol lung scan, ventilation scan, xenon lung scan.

AREA OF APPLICATION: Chest/thorax.

CONTRAST: Done with inhaled radioactive material (xenon gas or technetium-DTPA).

DESCRIPTION: The lung ventilation scan is a nuclear medicine study performed to evaluate a patient for pulmonary embolus (PE) or other pulmonary disorders. It can evaluate respiratory function (i.e., demonstrating areas of the lung that are patent and capable of ventilation) and

dysfunction (e.g., parenchymal abnormalities affecting ventilation, such as pneumonia). The procedure is performed after the patient inhales air mixed with a radioactive gas through a face mask and mouthpiece. The radioactive gas delineates areas of the lung during

ventilation. The distribution of the gas throughout the lung is measured in three phases:

Wash-in phase: Phase during buildup of the radioactive gas

Equilibrium phase: Phase after the patient rebreathes from a closed delivery system

Wash-out phase: Phase after the radioactive gas has been removed

This procedure is usually performed along with a lung perfusion scan. When PE is present, ventilation scans display a normal wash-in and wash-out of radioactivity from the lung areas. Parenchymal disease responsible for perfusion abnormalities will produce abnormal wash-in and wash-out phases. This test can be used to quantify regional ventilation in patients with pulmonary disease.

INDICATIONS:

- Aid in the diagnosis of PE
- Differentiate between PE and other pulmonary diseases, such as pneumonia, pulmonary effusion, atelectasis, asthma, bronchitis, emphysema, and tumors
- Evaluate regional respiratory function
- Identify areas of the lung that are capable of ventilation
- Locate hypoventilation (regional), which can result from chronic obstructive pulmonary disease (COPD) or excessive smoking

RESULT:

Normal findings in:

- Equal distribution of radioactive gas throughout both lungs and a normal wash-out phase

Abnormal findings in:

- Atelectasis
- Bronchitis

- Bronchogenic carcinoma
- COPD
- Emphysema
- PE
- Pneumonia
- Regional hypoventilation
- Sarcoidosis
- Tuberculosis
- Tumor

CRITICAL VALUES:

- Pulmonary embolism

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Other nuclear scans done within the preceding 24 to 48 hr

Other considerations:

- The presence of conditions that affect perfusion or ventilation (e.g., tumors that obstruct the pulmonary artery, vasculitis, pulmonary edema, sickle cell disease, parasitic disease, emphysema, effusion, infection) can simulate a perfusion defect similar to PE.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.

- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses airflow to the lungs.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's respiratory system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department, usually by a HCP who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in a supine position on a flat table with foam wedges, which help maintain position and immobilization.
- ▶ The radionuclide is administered through a mask, which is placed over the patient's nose and mouth. The patient is asked to hold his or her breathe for a short period of time while the scan is taken.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Evaluate the patient's vital signs. Monitor vital signs and neurological status every 15 min for one hr, then every 2 hr for 4 hr, and then as ordered by HCP. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Instruct the patient to resume medication, or activity, as directed by the HCP.
- ▶ Advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Tell the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.

- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include α -1 antitrypsin, alveolar/arterial ratio, ACE, angiography pulmonary, biopsy lung, blood gases, blood pool imaging, bronchoscopy, carbon dioxide, chest x-ray, complete blood count, complete blood count, CT thorax, complete blood count, WBC count and differential, culture and smear mycobacteria, culture blood, culture sputum, culture throat, culture viral, cytology sputum, D-dimer, gallium scan, lung perfusion scan, MRI chest, mediastinoscopy, plethysmography, pleural fluid analysis, PET heart, PFT, TB skin tests, US venous doppler extremity studies, and venography.
- ▶ Refer to the Respiratory System table at the back of the book for related tests by body system.

Lupus Anticoagulant Antibodies

SYNONYM/ACRONYM: Lupus inhibitor phospholipid type, lupus antiphospholipid antibodies, LA.

SPECIMEN: Plasma (1 mL) collected in blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Dilute Russell viper venom test time) Negative.

DESCRIPTION: Lupus anticoagulant antibodies (LA) are immunoglobulins, usually of the immunoglobulin G class. They are also referred to as lupus antiphospholipid antibodies because they interfere with phospholipid-dependent coagulation tests such as activated partial thromboplastin time (aPTT) by reacting with the phospholipids in the test system. They are not associated with a bleeding disorder unless thrombocytopenia or antiprothrombin antibodies are already present. They are associated with an increased risk of thrombosis.

- Rheumatoid arthritis (**LA can be detected with this condition and can cause vascular inflammation.**)
- Systemic lupus erythematosus (**Related to formation of thrombi as a result of LA binding to phospholipids on cell walls.**)
- Thromboembolism (**Related to formation of thrombi as a result of LA binding to phospholipids on cell walls.**)

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may cause a positive LA test result include calcium channel blockers, chlorpromazine, heparin, hydralazine, hydantoin, isoniazid, methyl dopa, phenytoin, phenothiazine, procainamide, quinine, quinidine, and thiazine.
- Placement of a tourniquet for longer than 1 min can result in venous stasis and changes in the concentration of plasma proteins to be measured. Platelet activation may also occur under these conditions, causing erroneous results.
- Vascular injury during phlebotomy can activate platelets and coagulation factors, causing erroneous results.

INDICATIONS:

- Evaluate prolonged aPTT
- Investigate reasons for fetal death

RESULT:

Positive findings in:

- Fetal loss (**Thrombosis associated with LA can form clots that lodge in the placenta and disrupt nutrition to the fetus.**)
- Raynaud's disease (**LA can be detected with this condition and can cause vascular inflammation.**)

- Hemolyzed specimens must be rejected because hemolysis is an indication of platelet and coagulation factor activation.
- Incompletely filled tubes contaminated with heparin or clotted specimens must be rejected.
- Icteric or lipemic specimens interfere with optical testing methods, producing erroneous results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate coagulation disorders.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic, immune, musculoskeletal, and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Heparin therapy should be discontinued 2 days before specimen collection, with medical direction. Coumarin therapy should be discontinued 2 wk before specimen collection, with medical direction.

- ▶ There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with pretesting preparations; assure that anticoagulant therapy has been restricted as required prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. *Important note:* Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range.
- ▶ When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and red-top tubes. When coagulation testing is the only test to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with tissue thromboplastin, which can falsely decrease values.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture

site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed samples stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection. If the patient has a known hematocrit above 55%, adjust the amount of anticoagulant in the collection tube before drawing the blood according to the CLSI guidelines:

$$\text{Anticoagulant vol. [x]} = \frac{(100 - \text{hematocrit})}{(595 - \text{hematocrit})} \times \text{total vol. of anticoagulated blood required}$$

Example:

$$\begin{aligned} \text{Patient hematocrit} &= 60\% = \\ &[(100 - 60)/(595 - 60) \times 5.0] = \\ &0.37 \text{ mL sodium citrate for a} \\ &5\text{-mL standard drawing tube} \end{aligned}$$

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications, as directed by the HCP.
- ▶ Recognize anxiety related to test results, and offer support. Provide teaching and information regarding the clinical implications of the test results,

as appropriate. It is also important to discuss feelings the mother and father may experience (e.g., guilt, depression, anger) if test results are abnormal. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the Lupus Foundation of America (www.lupus.org).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibody, anticardiolipin antibodies, anticyclic citrullinated peptide, ANA, arthroscopy, BMD, bone scan, CRP, ESR, FDP, MRI musculoskeletal, aPTT, protein S, PT/INR and mixing studies, radiography bone, RF, synovial fluid analysis, and US obstetric.
- ▶ Refer to the Hematopoietic, Immune, Musculoskeletal, and Reproductive System tables at the back of the book for related tests by body system.

Luteinizing Hormone

SYNONYM/ACRONYM: LH, luteotropin, interstitial cell–stimulating hormone (ICSH).

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Immunoassay)

Concentration by Sex and by Phase (in Women)**Conventional and SI Units**

<i>Male</i>	
Less than 2 yr	0.5–1.9 international units/mL
2–10 yr	Less than 0.5 international units/mL
11–20 yr	0.5–5.3 international units/mL
Adult	1.2–7.8 international units/mL
<i>Female</i>	
Less than 2–10 yr	Less than 0.5 international units/mL
11–20 yr	0.5–9.0 international units/mL
<i>Phase in Women</i>	
Follicular	1.7–15.0 international units/mL
Ovulatory	21.9–56.6 international units/mL
Luteal	0.6–16.3 international units/mL
Postmenopausal	14.2–52.3 international units/mL

DESCRIPTION: Luteinizing hormone (LH) is secreted by the anterior pituitary gland in response to stimulation by gonadotropin-releasing hormone, the same hypothalamic releasing factor that stimulates follicle-stimulating hormone release. LH affects gonadal function in both men and women. In women, a surge of LH normally occurs at the midpoint of the menstrual cycle (ovulatory phase); this surge is believed to be induced by high estrogen levels. LH causes the ovum to be expelled from the ovary and stimulates development of the corpus luteum and progesterone production. As progesterone levels rise, LH production decreases. In males, LH stimulates the interstitial cells of Leydig, located in the testes, to produce testosterone. For this reason, in reference to males, LH is sometimes called interstitial cell-stimulating hormone. Secretion of LH is pulsatile and follows a circadian rhythm in

response to the normal intermittent secretion of gonadotropin-releasing hormone.

INDICATIONS:

- Distinguish between primary and secondary causes of gonadal failure
- Evaluate children with precocious puberty
- Evaluate male and female infertility, as indicated by decreased LH levels
- Evaluate response to therapy to induce ovulation
- Support diagnosis of infertility caused by anovulation, as evidenced by lack of LH surge at the midpoint of the menstrual cycle

RESULT:

Increased in:
Conditions of decreased gonadal function cause a feedback response that stimulates LH secretion.

- Anorchia
- Gonadal failure
- Menopause
- Primary gonadal dysfunction

Decreased in:

- Anorexia nervosa
(*Pathophysiology is not clear*)
- Kallmann's syndrome
(*Pathophysiology is not clear*)
- Malnutrition (*Pathophysiology is not clear*)
- Pituitary or hypothalamic dysfunction (*These organs control production of LH; failure of the pituitary to produce LH or of the hypothalamus to produce gonadotropin-releasing hormone results in decreased LH levels*)
- Severe stress (*Pathophysiology is not clear*)

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs and hormones that may increase LH levels include clomiphene, gonadotropin-releasing hormone, goserelin, ketoconazole, mestranol, nafarelin, naloxone, nilutamide, spironolactone, and tamoxifen.
- Drugs and hormones that may decrease LH levels include anabolic steroids, anticonvulsants, conjugated estrogens, danazol, digoxin, D-Trp-6-LHRH, estrogen/progestin therapy, goserelin, megestrol, norethindrone, octreotide, oral contraceptives, phenothiazine, pimozide, pravastatin, progesterone, stanozolol, and tamoxifen.
- In menstruating women, values vary in relation to the phase of the menstrual cycle.
- LH secretion follows a circadian rhythm, with higher levels occurring during sleep.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to evaluate disorders of the hypothalamic-pituitary-gonadal axis.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. If the test is being performed to detect ovulation, inform the patient that it may be necessary to obtain a series of samples over a period of several days to detect peak LH levels. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any

concerns voiced by the patient or family.

- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ACTH, antisperm antibody, estradiol, FSH, progesterone, prolactin, and testosterone.
- Refer to the Endocrine and Reproductive System tables at the end of the book for related tests by body system.

Lyme Antibody

L

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect immunofluorescence) Negative.

DESCRIPTION: *Borrelia burgdorferi*, a deer tick-borne spirochete, is the organism that causes Lyme disease. Lyme disease affects multiple systems and is characterized by fever, arthralgia, and arthritis. The circular, red rash characterizing erythema migrans can appear 3 to 30 days after the tick bite. About one-half of patients in the early stage of Lyme disease (stage 1) and generally all of those in the advanced stage (stage 2)—with cardiac, neurologic, and rheumatoid manifestations—will have a positive test result.

Patients in remission will also have a positive test response. The presence of immunoglobulin M (IgM) antibodies indicates acute infection. The presence of IgG antibodies indicates current or past infection.

INDICATIONS:

Assist in establishing a diagnosis of Lyme disease

RESULT:

*Positive findings in:
Lyme disease*

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- High rheumatoid-factor titers as well as cross-reactivity with Epstein-Barr virus and other spirochetes (e.g., *Rickettsia*, *Treponema*) may cause false-positive results.
- Positive test results should be confirmed by the Western blot method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to detect antibodies to the organism that causes Lyme disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and musculoskeletal systems, symptoms, a history of exposure, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that several tests may be necessary to confirm diagnosis. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological

support before, during, and after the procedure.

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Advise the patient to wear light-colored clothing that covers extremities when in areas infested by deer ticks, and to check body for ticks after returning from infested area.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to perceived loss of independence, and fear of shortened life expectancy. Lyme disease can be debilitating and can result in significant changes in lifestyle. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.

L

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Warn the patient that false-positive test results can occur and that false-negative test results frequently occur. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease

process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ A related test is synovial fluid analysis.
- ▶ Refer to the Immune and Musculoskeletal System tables at the back of the book for related tests by body system.

Lymphangiography

SYNONYM/ACRONYM: Lymphangiogram.

AREA OF APPLICATION: Lymphatic system.

CONTRAST: IV iodine based contrast medium.

DESCRIPTION: Lymphangiography involves visualization of the lymphatic system after the injection of an iodinated oil-based contrast medium into a lymphatic vessel in the hand or foot. The lymphatic system consists of lymph vessels and nodes. Assessment of this system is important because cancer (lymphomas and Hodgkin's disease) often spreads via the lymphatic system. When the lymphatic system becomes obstructed, painful edema of the extremities usually results. The procedure is usually performed for cancer staging in patients with an established diagnosis of lymphoma or metastatic tumor. Injection into the hand allows

visualization of the axillary and supraclavicular nodes. Injection into the foot allows visualization of the lymphatics of the leg, inguinal and iliac regions, and retroperitoneum up to the thoracic duct. Less commonly, injection into the foot can be used to visualize the cervical region (retroauricular area). This procedure can assess progression of the disease, assist in planning surgery, and monitor the effectiveness of chemotherapy or radiation treatment.

INDICATIONS:

- Determine the extent of adenopathy

- Determine lymphatic cancer staging
- Distinguish primary from secondary lymphedema
- Evaluate edema of an extremity without known cause
- Evaluate effects of chemotherapy or radiation therapy
- Plan surgical treatment or evaluate effectiveness of chemotherapy or radiation therapy in controlling malignant tumors

RESULT:

Normal findings in:

- Normal lymphatic vessels and nodes that fill completely with contrast medium on the initial films. On 24-hr images, the lymph nodes are fully opacified and well circumscribed. The lymphatic channels are emptied a few hr after injection of the contrast medium.


Abnormal findings in:

- Abnormal lymphatic vessels
- Hodgkin's disease
- Metastatic tumor involving the lymph glands
- Nodal lymphoma
- Retroperitoneal lymphomas associated with Hodgkin's disease



CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with pulmonary insufficiencies, cardiac diseases, or severe renal or hepatic disease.
-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are pregnant or suspected of being pregnant, unless


the potential benefits of the procedure far outweigh the risks to the fetus and mother.

-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Inability to cannulate the lymphatic vessels

Other considerations:

-  Be aware of risks associated with the contrast medium. The oil-based contrast medium may embolize into the lungs and will temporarily diminish pulmonary function. This can produce lipid pneumonia, which is a life-threatening complication.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead

apron or leave the area while the examination is being done.

Personnel working in the examination area should wear badges to record their level of radiation exposure.

- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the lymphatic system.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to iodine, latex, seafood, anesthetics, or contrast mediums.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium. Ensure that barium studies were performed more than 4 days before lymphangiography.
- ▶ Obtain a history of the patient's endocrine and immunological systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is performed by a HCP, with support staff, and takes approximately 1 to 2 hr. Inform the

patient that he or she will have to return the next day, and the set of images taken upon return will take only 30 min.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct patient to withhold anti-coagulant medication or to reduce dosage before the procedure, as ordered by the HCP.
- ▶ There are no food or fluid restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has complied with medication restrictions and pretesting preparations.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily accessible.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Obtain and record baseline vital signs, and assess neurological status.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer a mild sedative, as ordered.
- ▶ Place the patient in a supine position on an x-ray table. Cleanse the selected area and cover with a sterile drape.

- ▶ A local anesthetic is injected at the site, and a small incision is made or a needle inserted. A blue dye is injected intradermally into the area between the toes or fingers. The lymphatic vessels are identified as the dye moves. A local anesthetic is then injected into the dorsum of each foot or hand, and a small incision is made and cannulated for injection of the contrast medium.
- ▶ The contrast medium is then injected, and the flow of the contrast medium is followed by fluoroscopy or images. When the contrast medium reaches the upper lumbar level, the infusion of contrast medium is discontinued. X-ray images are taken of the chest, abdomen, and pelvis to determine the extent of filling of the lymphatic vessels. Twenty-four-hour delayed images are taken to examine the lymphatic nodes and to monitor the progress of delayed flow.
- ▶ Monitor the patient for complications related to the contrast medium (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ When the procedure is complete, the cannula is removed and the incision sutured and bandaged.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Monitor vital signs and neurological status every 15 min for 30 min. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe the cannula insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Observe for a delayed allergic reaction to contrast medium or pulmonary embolus, which may include shortness of breathe, increased heart rate, pleuritic pain, hypotension, low-grade fever, and cyanosis.

- ▶ Advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Instruct the patient to resume usual medications, as directed by the HCP.
- ▶ Instruct the patient to maintain bed rest up to 24 hr to reduce extremity swelling after the procedure, or as ordered.
- ▶ Instruct the patient to apply cold compresses to the cannulated site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, biopsy lymph nodes, complete blood count, complete blood count, WBC count and differential, CT abdomen, CT pelvis, CT thoracic, gallium scan, laparoscopy abdominal, liver and spleen scan, MRI abdomen, mediastinoscopy, and US lymph nodes.
- ▶ Refer to the Endocrine and Immune System tables in the back of the book for tests by related body system.

Magnesium, Blood

SYNONYM/ACRONYM: Mg²⁺.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	Alternative Units (Conventional Units × 0.8229)	SI Units (Conventional Units × 0.4114)
Newborn	1.5–2.2 mg/dL	1.23–1.81 mEq/L	0.62–0.91 mmol/L
Child	1.7–2.1 mg/dL	1.40–1.73 mEq/L	0.70–0.86 mmol/L
Adult	1.6–2.6 mg/dL	1.32–2.14 mEq/L	0.66–1.07 mmol/L

DESCRIPTION: Magnesium is required as a cofactor in numerous crucial enzymatic processes, such as protein synthesis, nucleic acid synthesis, and muscle contraction. Magnesium is also required for the use of adenosine diphosphate as a source of energy. It is the fourth most abundant cation and the second most abundant intracellular ion. Magnesium is needed for the transmission of nerve impulses and muscle relaxation. It controls absorption of sodium, potassium, calcium, and phosphorus; utilization of carbohydrate, lipid, and protein; and activation of enzyme systems that enable the B vitamins to function. Magnesium is also essential for oxidative phosphorylation, nucleic acid synthesis, and blood clotting. Urine magnesium levels reflect magnesium deficiency before serum levels. Magnesium deficiency severe enough to cause hypocalcemia and cardiac arrhythmias can exist despite normal serum magnesium levels.

INDICATIONS:

- Determine electrolyte balance in renal failure and chronic alcoholism
- Evaluate cardiac arrhythmias (decreased magnesium levels can

lead to excessive ventricular irritability)

- Evaluate known or suspected disorders associated with altered magnesium levels
- Monitor the effects of various drugs on magnesium levels

RESULT:

Increased in:

- Addison's disease (**Related to insufficient production of aldosterone; decreased renal excretion**)
- Adrenocortical insufficiency (**Decreased renal excretion**)
- Dehydration (**Decreased volume reflects hemoconcentration**)
- Diabetic acidosis (severe) (**Disturbance is a function of acid-base imbalance**)
- Hypothyroidism (**Pathophysiology is unclear**)
- Massive hemolysis (**Intracellular concentration is three times higher than normal plasma levels**)
- Overuse of antacids (**Excessive intake of magnesium-containing antacids**)
- Renal insufficiency (**Related to decreased urinary excretion**)
- Tissue trauma

Decreased in:

- Alcoholism (**Related to increased renal excretion and possible insufficient dietary intake**)

- Diabetic acidosis (***Insulin treatment lowers blood glucose and appears to increase intracellular transport of magnesium***)
- Glomerulonephritis (chronic) (***Related to diminished renal function; magnesium is reabsorbed in the renal tubules***)
- Hemodialysis (***Loss of magnesium due to dialysis treatment***)
- Hyperaldosteronism (***Related to increased excretion***)
- Hypocalcemia (***Decreased magnesium is associated with decreased calcium and vitamin D levels***)
- Hypoparathyroidism (***Related to decreased calcium***)
- Inadequate intake
- Inappropriate secretion of antidiuretic hormone (***Related to fluid overload***)
- Long-term hyperalimentation
- Malabsorption (***Related to impaired absorption of calcium and vitamin D***)
- Pancreatitis (***Secondary to alcoholism***)
- Pregnancy
- Severe loss of body fluids (***Diarrhea, lactation, sweating, laxative abuse***)

CRITICAL VALUES:

Less than 1.2 mg/dL

Greater than 4.9 mg/dL

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

Symptoms such as tetany, weakness, dizziness, tremors, hyperactivity, nausea, vomiting, and convulsions occur at decreased (less than 1.2 mg/dL) concentrations. Electrocardiographic (ECG) changes (prolonged P-R and Q-T intervals, broad flat T waves, and ventricular tachycardia) may also occur. Treatment may include IV or oral administration of

magnesium salts, monitoring for respiratory depression and areflexia (IV administration of magnesium salts), and monitoring for diarrhea and metabolic alkalosis (oral administration to replace magnesium).

Respiratory paralysis, decreased reflexes, and cardiac arrest occur at grossly elevated (greater than 15 mg/dL) levels. ECG changes, such as prolonged P-R and Q-T intervals, and bradycardia may be seen. Toxic levels of magnesium may be reversed with the administration of calcium, dialysis treatments, and removal of the source of excessive intake.

INTERFERING FACTORS:

- Drugs that may increase magnesium levels include acetylsalicylic acid and progesterone.
- Drugs that may decrease magnesium levels include albuterol, aminoglycosides, amphotericin B, bendroflumethiazide, chlorthalidone, cisplatin, citrates, cyclosporines, digoxin, gentamicin, glucagon, and oral contraceptives.
- Hemolysis results in a false elevation in values; such specimens should be rejected for analysis.
- Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, falsely decreasing the result. There is also the potential of contaminating the sample with the substance of interest, if it is present in the IV solution, falsely increasing the result.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to assist in the evaluation of electrolyte balance.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular, endocrine, gastrointestinal, genitourinary, and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Educate the magnesium-deficient patient regarding good dietary sources of magnesium, such as green vegetables, seeds, legumes, shrimp, and some bran cereals. Advise the patient that high intake of substances such as phosphorus, calcium, fat, and protein interferes with the absorption of magnesium.
- ▶ Instruct the patient to report any signs or symptoms of electrolyte imbalance, such as dehydration, diarrhea, vomiting, or prolonged anorexia.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, aldosterone, anion gap, antiarrhythmic drugs, AST, BUN, calcium, calculus kidney stone panel, complete blood count, WBC count and differential, cortisol, CRP, CK and isoenzymes, creatinine, glucose, homocysteine, LDH and isoenzymes, magnesium urine, myoglobin, osmolality, PTH, phosphorus, potassium, renin, sodium, troponin, and vitamin D.
- ▶ Refer to the Cardiovascular, Endocrine, Gastrointestinal, Genitourinary, and Reproductive System tables at the back of the book for related tests by body system.

Magnesium, Urine

SYNONYM/ACRONYM: Urine Mg^{2+} .

SPECIMEN: Urine (5 mL) from a random or timed specimen collected in a clean plastic collection container with 6N hydrochloride as a preservative.

REFERENCE VALUE: (Method: Spectrophotometry)

Conventional	Alternative Units (Conventional Units \times 0.8229)	SI Units (Conventional Units \times 0.4114)
7.3–12.2 mg/24 hr	6.0–10.0 mEq/24 hr	3.0–5.0 mmol/24 hr

DESCRIPTION: Magnesium is required as a cofactor in numerous crucial enzymatic processes, such as protein synthesis, nucleic acid synthesis, and muscle contraction. Magnesium is also required for the use of adenosine diphosphate as a source of energy. It is the fourth most abundant cation and the second most abundant intracellular ion. Magnesium is needed for the transmission of nerve impulses and muscle relaxation. It controls absorption of sodium, potassium, calcium, and phosphorus; utilization of carbohydrate, lipid, and protein; and activation of enzyme systems that enable the B vitamins to function. Magnesium is also essential for oxidative phosphorylation, nucleic acid synthesis, and blood clotting. Urine magnesium levels reflect magnesium deficiency before serum levels. Magnesium deficiency severe enough to cause hypocalcemia and cardiac arrhythmias can exist despite normal serum magnesium levels.

Regulating electrolyte balance is one of the major functions of the kidneys. In normally

functioning kidneys, urine levels increase when serum levels are high and decrease when serum levels are low to maintain homeostasis. Analyzing these urinary levels can provide important clues as to the functioning of the kidneys and other major organs. Tests for electrolytes, such as magnesium, in urine usually involve timed urine collections over a 12- or 24-hr period. Measurement of random specimens may also be requested.

INDICATIONS:

- Determine the potential cause of renal calculi
- Evaluate known or suspected endocrine disorder
- Evaluate known or suspected renal disease
- Evaluate magnesium imbalance
- Evaluate a malabsorption problem

RESULT:

Increased in:

- Alcoholism (*Related to impaired absorption and increased urinary excretion*)

- Bartter's syndrome (**Inherited defect in renal tubules that results in urinary wasting of potassium and magnesium**)
- Transplant recipients on cyclosporine and prednisone (**These medications cause the kidney to increase excretion**)
- Use of corticosteroids (**These medications cause the kidney to increase excretion**)
- Use of diuretics (**Increased urinary excretion**)

Decreased in:

- Abnormal renal function (**Related to diminished ability of renal tubules to reabsorb magnesium**)
- Crohn's disease (**Related to inadequate intestinal absorption**)
- Inappropriate secretion of antidiuretic hormone (**Related to diminished renal absorption**)
- Salt-losing conditions (**Related to diminished renal absorption**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase urine magnesium levels include cisplatin, cyclosporine, ethacrynic acid, furosemide, mercaptopimerin, mercurial diuretics, and thiazides.
- Drugs that may decrease urine magnesium levels include amiloride, angiotensin, oral contraceptives, parathyroid extract, and phosphates.
- Magnesium levels follow a circadian rhythm, and for this reason 24-hr collections are recommended.
- All urine voided for the timed collection period must be included in the collection, or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate magnesium balance.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine, gastrointestinal, and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain related to the procedure. Explain to the patient that there should be no discomfort during the procedure.
- ♦ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ♦ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ Instruct the patient to avoid excessive exercise and stress during the 24-hr collection of urine.

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with activity restrictions during the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and

discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.

- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- ▶ Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that can affect test results.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Educate the magnesium-deficient patient regarding good dietary sources of magnesium, such as green vegetables, seeds, legumes, shrimp, and some bran cereals. Advise the patient that high intake of substances such as phosphorus, calcium, fat, and protein interferes with the absorption of magnesium.
- ▶ Instruct the patient to report any signs or symptoms of electrolyte imbalance, such as dehydration, diarrhea, vomiting, or prolonged anorexia.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, aldosterone, angiography renal, anion gap, BUN, calcium, calculus kidney stone panel, CT renal, cortisol, creatinine, glucose, IVP, magnesium, osmolality, PTH, phosphorus, potassium, renin, renogram, sodium, troponin, UA, US kidney, and vitamin D.
- ▶ Refer to the Endocrine, Gastrointestinal, and Genitourinary System tables at the back of the book for related tests by body system.

Magnetic Resonance Angiography

SYNONYM/ACRONYM: MRA.

AREA OF APPLICATION: Vascular.

CONTRAST: Can be done with or without IV contrast (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of the vessels in multiple planes without the use of ionizing radiation or the interference of bone or surrounding tissue.

Magnetic resonance angiography (MRA) is an application of

MRI that provides images of blood flow and diseased and normal blood vessels. In patients who are allergic to iodinated contrast medium, MRA is used in place of angiography. MRA is particularly useful for visualizing vascular abnormalities, dissections, and other pathology. Special imaging sequences allow the visualization of moving blood within the vascular system. Two common techniques to obtain images of flowing blood are time-of-flight and phase-contrast MRA. In time-of-flight imaging, incoming blood makes the vessels appear bright and surrounding tissue is suppressed. Phase-contrast images are produced by subtracting the stationary tissue surrounding the vessels where the blood is moving through vessels during the imaging, producing high-contrast images. MRA is the most accurate

technique for imaging blood flow in veins and small arteries (*laminar flow*), but it does not accurately depict blood flow in tortuous sections of vessels and distal to bifurcations and stenosis. Swirling blood may cause a signal loss and result in inadequate images, and the degree of vessel stenosis may be overestimated. Images can be obtained in two-dimensional (series of slices) or three-dimensional sequences.

INDICATIONS:

- Detect pericardial abnormalities
- Detect peripheral vascular disease
- Detect thoracic and abdominal vascular diseases
- Determine renal artery stenosis
- Differentiate aortic aneurysms from tumors near the aorta
- Evaluate cardiac chambers and pulmonary vessels
- Evaluate postoperative angioplasty sites and bypass grafts
- Identify congenital vascular diseases
- Monitor and evaluate the effectiveness of medical or surgical treatment

RESULT:

Normal findings in:

- Normal blood flow in the area being examined, including blood flow rate

Abnormal findings in:

- Coarctations
- Dissections
- Thrombosis within a vessel
- Tumor invasion of a vessel
- Vascular abnormalities
- Vessel occlusion
- Vessel stenosis



CRITICAL VALUES:

- Aortic aneurysm
- Aortic dissection
- Occlusion
- Tumor with significant mass effect
- Vertebral artery dissection

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with certain ferrous metal prosthetics, valves, aneurysm clips, inner ear prostheses, or other metallic objects
- Patients with metal in their body, such as shrapnel or ferrous metal in the eye
-  Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
-  Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73m²). Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.
- Patients who are claustrophobic
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Patients with extreme cases of claustrophobia, unless sedation is given before the study

Other considerations:

- If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the vascular system.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of results of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.
- ▶ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ▶ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals (see Appendix F).
- ▶ Review the procedure with the patient. Address concerns about pain related

to the procedure and explain that no pain will be experienced during the test, but there may be moments of discomfort. Reassure the patient that if contrast is used, it poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in an MRI department by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ Inform the patient that the technologist will place him or her in a supine position on a flat table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove external metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout

the procedure because movement produces unreliable results.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.
- ▶ If an electrocardiogram or respiratory gating is to be performed in conjunction with the scan, apply MRI-safe electrodes to the appropriate sites.
- ▶ Establish IV fluid line for the injection of emergency drugs and sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia,

hyperpnea, hypertension, palpitations, nausea, or vomiting.

- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography of the body area of interest, BUN, CT angiography, creatinine, US arterial Doppler carotid, and US venous Doppler.
- ▶ Refer to the Cardiovascular System table at the back of the book for related tests by body system.

Magnetic Resonance Imaging, Abdomen

SYNONYM/ACRONYM: Abdominal MRI.

AREA OF APPLICATION: Liver/abdominal area.

CONTRAST: Can be done with or without IV contrast medium (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. Use of magnetic fields with the aid of radio frequency energy produces images primarily based on water content of tissue. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of the abdomen in multiple planes without the use of ionizing radiation or the interference of bone.



Abdominal MRI is performed to assist in diagnosing abnormalities of abdominal and hepatic structures. Contrast-enhanced imaging is effective for distinguishing peritoneal metastases from primary tumors of the gastrointestinal tract. Primary tumors of the stomach, pancreas, colon, and appendix often spread by intraperitoneal tumor

shedding and subsequent peritoneal carcinomatosis. MRI uses the noniodinated contrast medium gadopentetate dimeglumine (Magnevist), which is administered IV to enhance contrast differences between normal and abnormal tissues.

Magnetic resonance angiography (MRA) is an application of MRI that provides images of blood flow and diseased and normal blood vessels. In patients who are allergic to iodinated contrast medium, MRA is used in place of angiography (see monograph titled “Magnetic Resonance Angiography”).

INDICATIONS:

- Detect abdominal aortic diseases
- Detect and stage cancer (primary or metastatic tumors of liver, pancreas, prostate, uterus, and bladder)
- Detect chronic pancreatitis
- Detect renal vein thrombosis
- Detect soft tissue abnormalities
- Determine and monitor tissue damage in renal transplant patients
- Determine the presence of blood clots, cysts, fluid or fat accumulation in tissues, hemorrhage, and infarctions
- Determine vascular complications of pancreatitis, venous thrombosis, or pseudoaneurysm

- Differentiate aortic aneurysms from tumors near the aorta
- Differentiate liver tumors from liver abnormalities, such as cysts, cavernous hemangiomas, and hepatic amebic abscesses
- Evaluate postoperative angioplasty sites and bypass grafts
- Monitor and evaluate the effectiveness of medical or surgical interventions and the course of the disease
-  Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
-  Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73m²). Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.

RESULT:

Normal findings in:

- Normal anatomic structures, soft tissue density, and biochemical constituents of body tissues, including blood flow

Abnormal findings in:

- Acute tubular necrosis
- Aneurysm
- Cholangitis
- Glomerulonephritis
- Hydronephrosis
- Internal bleeding
- Masses, lesions, infections, or inflammations
- Renal vein thrombosis
- Vena cava obstruction


CRITICAL VALUES:

- Acute GI bleed
- Aortic aneurysm
- Infection
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with certain ferrous metal prostheses, valves, aneurysm clips, inner ear prostheses, or other metallic objects
-  Patients with metal in their body, such as shrapnel or ferrous metal in the eye

- Patients with intrauterine devices
- Patients with iron pigments in tattoos
- Patients who are claustrophobic
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Patients with extreme cases of claustrophobia, unless sedation is given before the study or an open MRI is utilized

Other considerations:

- If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the organs and structures inside the abdomen.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of results of the patient's gastrointestinal, genitourinary, and hepatobiliary systems, symptoms, and results of previously performed laboratory tests, diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.
- ▶ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ▶ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that no pain will be experienced during the test, but there may be

moments of discomfort. Reassure the patient that if contrast is used, it poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in an MRI department by a health care provider (HCP) specializing in this procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ Inform the patient that the technologist will place him or her in a supine position on a flat table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ Instruct the patient to remove jewelry and all other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images are taken and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH and challenge tests, angiography abdomen, BUN, cortisol and challenge tests, CT abdomen; creatinine, KUB study, and US liver and biliary system.
- ▶ Refer to the Gastrointestinal, Genitourinary, and Hepatobiliary System tables at the back of the book for related tests by body system.

Magnetic Resonance Imaging, Brain

SYNONYM/ACRONYM: Brain MRI.

AREA OF APPLICATION: Brain area.

CONTRAST: Can be done with or without IV contrast medium (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. Use of magnetic fields with the aid of radiofrequency energy produces images primarily based on water content of tissue. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of pathological lesions of the brain in multiple planes without the use of ionizing radiation or the interference of bone or surrounding tissue.

Brain MRI can distinguish solid, cystic, and hemorrhagic components of lesions. This procedure is done to aid in the diagnosis of intracranial abnormalities, including tumors, ischemia, infection, and multiple sclerosis, and in assessment of brain maturation in pediatric patients. Rapidly flowing blood on spin-echo MRI appears as an absence of signal or a void in the vessel's lumen.

Blood flow can be evaluated in the cavernous and carotid arteries. Aneurysms may be diagnosed without traditional iodine-based contrast angiography, and old clotted blood in the walls of the aneurysms appears white. MRI uses the noniodinated contrast medium gadopentetate dimeglumine (Magnevist), which is administered IV to enhance contrast differences between normal and abnormal tissues.

Magnetic resonance angiography (MRA) is an application of MRI that provides images of blood flow and diseased and normal blood vessels. In patients who are allergic to iodinated contrast medium, MRA is used in place of angiography (see monograph titled "Magnetic Resonance Angiography").

INDICATIONS:

- Detect and locate brain tumors
- Detect cause of cerebrovascular accident, cerebral infarct, or hemorrhage
- Detect cranial bone, face, throat, and neck soft tissue lesions
- Evaluate the cause of seizures, such as intracranial infection, edema, or increased intracranial pressure
- Evaluate cerebral changes associated with dementia
- Evaluate demyelinating disorders
- Evaluate intracranial infections
- Evaluate optic and auditory nerves

- Evaluate the potential causes of headache, visual loss, and vomiting
- Evaluate shunt placement and function in patients with hydrocephalus
- Evaluate the solid, cystic, and hemorrhagic components of lesions
- Evaluate vascularity of the brain and vascular integrity
- Monitor and evaluate the effectiveness of medical or surgical interventions, chemotherapy, radiation therapy, and the course of disease

RESULT:

Normal findings in:

- Normal anatomic structures, soft tissue density, blood flow rate, face, nasopharynx, neck, tongue, and brain

Abnormal findings in:

- Abscess
- Acoustic neuroma
- Alzheimer's disease
- Aneurysm
- Arteriovenous malformation
- Benign meningioma
- Cerebral aneurysm
- Cerebral infarction
- Craniopharyngioma or meningioma
- Granuloma
- Intraparenchymal hematoma or hemorrhage
- Lipoma
- Metastasis
- Multiple sclerosis
- Optic nerve tumor
- Parkinson's disease
- Pituitary microadenoma
- Subdural empyema
- Ventriculitis




CRITICAL VALUES:

- Abscess
- Cerebral aneurysm
- Cerebral infarct
- Hydrocephalus
- Skull fracture or contusion
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with certain ferrous metal prostheses, valves, aneurysm clips, inner ear prostheses, or other metallic objects
-  Patients with metal in their body, such as shrapnel or ferrous metal in the eye
-  Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
-  Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73 m²). Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.
- Patients with intrauterine devices
- Patients with iron pigments in tattoos
- Patients who are claustrophobic
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Patients with extreme cases of claustrophobia, unless sedation is given before the study or an open MRI is utilized

Other considerations:

- If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the brain.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of results of the patient's cardiovascular and endocrine systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.
- ▶ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ▶ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the

patient that no pain will be experienced during the test, but there may be moments of discomfort. Reassure the patient that if contrast is used, it poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in an MRI department, usually by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ Inform the patient that the technologist will place him or her in a supine position on a flat table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ Instruct the patient to remove jewelry and all other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.

- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.
- ▶ If an electrocardiogram or respiratory gating is to be performed in conjunction with the scan, apply MRI-safe electrodes to the appropriate sites.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an anti-anxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations,

nausea, or vomiting, if contrast medium was used.

- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include Alzheimer disease markers, angiography of the carotids, BUN, CSF analysis, CT brain, creatinine, EMG, evoked brain potentials, and PET brain.
- ▶ Refer to the Cardiovascular and Endocrine System tables at the back of the book for related tests by body system.

M

Magnetic Resonance Imaging, Breast

SYNONYM/ACRONYM: Breast MRI.

AREA OF APPLICATION: Breast area.

CONTRAST: Can be done with or without IV contrast medium (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. Use of magnetic fields with the aid of radiofrequency energy produces images primarily based on water content of tissue. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of the pathological lesions in multiple planes without the use of ionizing radiation or the interference of surrounding tissue, breast implants, or surgically implanted clips.

MRI imaging of the breast is not a replacement for traditional mammography, ultrasound, or biopsy. This exam is extremely helpful in evaluating mammogram abnormalities and identifying early breast cancer in women at high risk. High-risk women include those who have had breast cancer, have an abnormal mutated breast cancer gene (BRCA1 or BRCA2), or have a mother or sister who has been diagnosed with breast cancer. Breast MRI is used most commonly in high-risk women when findings of a mammogram or ultrasound are inconclusive because of dense breast tissue or there is a suspected abnormality that requires further evaluation. MRI is also an excellent exam in the augmented

breast, including both the breast implant itself and the breast tissue surrounding the implant. This same exam is also useful for staging breast cancer and determining the most appropriate treatment. MRI uses the noniodinated contrast medium gadopentetate dimeglumine (Magnevist), which is administered IV to enhance contrast differences between normal and abnormal tissues.

INDICATIONS:

- Evaluate breast implants
- Evaluate dense breasts
- Evaluate for residual cancer after lumpectomy
- Evaluate inverted nipples
- Evaluate small abnormalities
- Evaluate tissue after lumpectomy or mastectomy
- Evaluate women at high risk for breast cancer

RESULT:

Normal findings in:

- Normal anatomic structures, soft tissue density, and blood flow rate


Abnormal findings in:

- Breast abscess or cyst
- Breast cancer
- Breast implant rupture
- Hematoma
- Soft tissue masses
- Vascular abnormalities

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with certain ferrous metal prostheses, valves, aneurysm clips, inner ear prostheses, or other metallic objects
-  Patients with metal in their body, such as shrapnel or ferrous metal in the eye

- ◆ Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
- ◆ Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73 m²). Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.
- ◆ Patients with intrauterine devices
- ◆ Patients with iron pigments in tattoos
- ◆ Patients who are claustrophobic
- ◆ Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- ◆ Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- ◆ Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- ◆ Patients with extreme cases of claustrophobia, unless sedation is given before the study or an open MRI is utilized

Other considerations:

- ◆ If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.
- ◆ The procedure can be nonspecific; the exam is unable to image calcifications that can indicate breast cancer, and there may be difficulty distinguishing between cancerous and noncancerous tumors.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure assesses the breast.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ◆ Obtain a history of results of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.
- ◆ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ◆ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ◆ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ◆ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ◆ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no pain will be experienced during the test, but there may be moments of discomfort. Reassure the patient that if contrast is used, it poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in an MRI department by a health care provider (HCP) who specializes in this

procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ Inform the patient that the technologist will place him or her in a prone position on a special imaging table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ Instruct the patient to remove jewelry and all other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.

- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the prone position on a special exam table designed for breast imaging.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include biopsy breast, bone scan, BUN, cancer antigens, CT thorax, creatinine, mammogram, stereotactic biopsy breast, and US breast.
- Refer to the Reproductive System table at the back of the book for related tests by body system.

Magnetic Resonance Imaging, Chest

SYNONYM/ACRONYM: Chest MRI.

AREA OF APPLICATION: Chest/thorax.

CONTRAST: Can be done with or without IV contrast medium (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. Use of magnetic fields with the aid of radiofrequency energy produces images primarily based on water content of tissue. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of pathological lesions in multiple planes without the use of ionizing radiation or the interference of bone or surrounding tissue.

Chest MRI scanning is performed to assist in diagnosing abnormalities of cardiovascular and pulmonary structures. Two special techniques are available for evaluation of cardiovascular structures. One is the electrocardiograph (ECG)-gated multislice spin-echo sequence, used to diagnose anatomic abnormalities of the heart and aorta, and the other is the ECG-referenced gradient refocused sequence, used to diagnose heart function and analyze blood flow patterns.

Magnetic resonance angiography (MRA) is an application of MRI that provides images of blood flow and diseased and normal blood vessels. In patients who are allergic to iodinated contrast medium, MRA is used in place of angiography (see monograph titled "Magnetic Resonance Angiography").

INDICATIONS:

- Confirm diagnosis of cardiac and pericardiac masses
- Detect aortic aneurysms
- Detect myocardial infarction and cardiac muscle ischemia
- Detect pericardial abnormalities
- Detect pleural effusion
- Detect thoracic aortic diseases
- Determine blood, fluid, or fat accumulation in tissues, pleuritic space, or vessels
- Determine cardiac ventricular function
- Differentiate aortic aneurysms from tumors near the aorta
- Evaluate cardiac chambers and pulmonary vessels
- Evaluate postoperative angioplasty sites and bypass grafts
- Identify congenital heart diseases
- Monitor and evaluate the effectiveness of medical or surgical therapeutic regimen

RESULT:**Normal findings in:**

- Normal heart and lung structures, soft tissue, and function, including blood flow rate

Abnormal findings in:




- Aortic dissection
- Congenital heart diseases, including pulmonary atresia, aortic coarctation, agenesis of the pulmonary artery, and transposition of the great vessels
- Constrictive pericarditis
- Intramural and periaortic hematoma
- Myocardial infarction
- Pericardial hematoma or effusion
- Pleural effusion

CRITICAL VALUES:

- Aortic aneurysm
- Aortic dissection
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:**This procedure is contraindicated for:**

- Patients with certain ferrous metal prostheses, valves, aneurysm clips, inner ear prostheses, or other metallic objects
-  Patients with metal in their body, such as shrapnel or ferrous metal in the eye
-  Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
-  Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73 m²). Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.
- Patients with intrauterine devices
- Patients with iron pigments in tattoos
- Patients who are claustrophobic
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Patients with extreme cases of claustrophobia, unless sedation is given before the study or an open MRI is utilized

Other considerations:

- If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the organs and structures inside the chest.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's cardiovascular and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.
- ▶ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ▶ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no pain will be experienced during the test, but there may be moments of discomfort. Reassure the patient that if contrast is used, it poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in an MRI department, usually by a health care provider (HCP) who specializes in these procedures, with support staff, and takes approximately 30 to 60 min.
- ▶ Inform the patient that the technologist will place him or her in a supine position on a flat table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ Instruct the patient to remove jewelry and all other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.

- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.
- ▶ If an electrocardiogram or respiratory gating is to be performed in conjunction with the scan, apply MRI-safe electrodes to the appropriate sites.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images are taken and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia,

hyperpnea, hypertension, palpitations, nausea, or vomiting.

- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include AST, BNP, blood gases, blood pool imaging, BUN, chest x-ray, CT cardiac scoring, CT thorax, CRP, CK and isoenzymes, creatinine, echocardiography, exercise stress test, Holter monitor, myocardial infarct scan, myocardial perfusion heart scan, myoglobin, pleural fluid analysis, PET scan of the heart, and troponins.
- ▶ Refer to the Cardiovascular and Respiratory System tables at the back of the book for related tests by body system.

Magnetic Resonance Imaging, Musculoskeletal

SYNONYM/ACRONYM: Musculoskeletal (knee, shoulder, hand, wrist, foot, elbow, hip) MRI.

AREA OF APPLICATION: Bones, joints, soft tissues.

CONTRAST: Can be done with or without IV contrast medium (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. Use of magnetic fields with the aid of radiofrequency energy produces images primarily based on water content of tissue. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of bones and joints in multiple planes without the use of ionizing radiation or the interference of bone or surrounding tissue.

Musculoskeletal MRI is performed to assist in diagnosing abnormalities of bones and joints and surrounding soft tissue structures, including cartilage, synovium, ligaments, and tendons. MRI eliminates the risks associated with exposure

to x-rays and causes no harm to cells. Contrast-enhanced imaging is effective for evaluating scarring from previous surgery, vascular abnormalities, and differentiation of metastases from primary tumors. MRI uses the noniodinated contrast medium gadopentetate dimeglumine (Magnevist), which is administered IV to enhance contrast differences between normal and abnormal tissues.

Magnetic resonance angiography (MRA) is an application of MRI that provides images of blood flow and diseased and normal blood vessels. In patients who are allergic to iodinated contrast medium, MRA is used in place of angiography (see monograph titled “Magnetic Resonance Angiography”).

INDICATIONS:

- Confirm diagnosis of osteomyelitis
- Detect avascular necrosis of the femoral head or knee
- Detect benign and cancerous tumors and cysts of the bone or soft tissue
- Detect bone infarcts in the epiphyseal or diaphyseal sites
- Detect changes in bone marrow

- Detect tears or degeneration of ligaments, tendons, and menisci resulting from trauma or pathology
- Determine cause of low back pain, including herniated disk and spinal degenerative disease
- Differentiate between primary and secondary malignant processes of the bone marrow
- Differentiate between a stress fracture and a tumor
- Evaluate meniscal detachment of the temporomandibular joint

RESULT:

Normal findings in:

- Normal bones, joints, and surrounding tissue structures; no articular disease, bone marrow disorders, tumors, infections, or trauma to the bones, joints, or muscles

Abnormal findings in:

- Avascular necrosis of femoral head or knee, as found in Legg-Calvé-Perthes disease
- Bone marrow disease, such as Gaucher's disease, aplastic anemia, sickle cell disease, or polycythemia
- Degenerative spinal disease, such as spondylosis or arthritis
- Fibrosarcoma
- Hemangioma (muscular or osseous)
- Herniated disk
- Infection
- Meniscal tears or degeneration
- Osteochondroma
- Osteogenic sarcoma
- Osteomyelitis
- Rotator cuff tears
- Spinal stenosis
- Stress fracture
- Synovitis
- Tumor




CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with certain ferrous metal prostheses, valves, aneurysm clips,

inner ear prostheses, or other metallic objects

-  Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
-  Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73m²). Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.
-  Patients with metal in their body, such as shrapnel or ferrous metal in the eye
- Patients with intrauterine devices
- Patients with iron pigments in tattoos
- Patients who are claustrophobic
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

This procedure is contraindicated for:

- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Patients with extreme cases of claustrophobia, unless sedation is given before the study or an open MRI is utilized

Other considerations:

- If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses muscles, bones, and joints.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of results of the patient's cardiovascular and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.
- ▶ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ▶ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no pain will be experienced during the test, but there may be

moments of discomfort. Reassure the patient that if contrast is used, it poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in an MRI department, usually by a health care provider (HCP) specializing in this procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ Inform the patient that the technologist will place him or her in a supine position on a flat table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ Instruct the patient to remove jewelry, and all other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an anti-anxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

M

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting, if contrast medium was used.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include anticyclic citrullinated antibodies, ANA, arthro-gram, arthroscopy, bone mineral densitometry, bone scan, BUN, CRP, CT spine, creatinine, ESR, radiography of the bone, synovial fluid analysis, RF, and vertebroplasty.
- ▶ Refer to the Cardiovascular and Musculoskeletal System tables at the back of the book for related tests by body system.

Magnetic Resonance Imaging, Pancreas

SYNONYM/ACRONYM: Pancreatic MRI.

AREA OF APPLICATION: Pancreatic/upper abdominal area.

CONTRAST: Can be done with or without IV contrast medium (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. Use of magnetic fields with the aid of radiofrequency energy produces images primarily based on water content of tissue. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of the abdominal area in multiple planes without the use of ionizing radiation or the interference of bone or surrounding tissue.

MRI of the pancreas is employed to evaluate small pancreatic adenocarcinomas, islet cell tumors, ductal abnormalities and calculi, or parenchymal abnormalities. A T1-weighted, fat-saturation series of images is probably best for evaluating the pancreatic parenchyma. This sequence is ideal for showing fat planes between the pancreas and

peripancreatic structures and for identifying abnormalities, such as fatty infiltration of the pancreas, hemorrhage, adenopathy, and carcinomas. T2-weighted images are most useful for depicting intrapancreatic or peripancreatic fluid collections, pancreatic neoplasms, and calculi. Imaging sequences can be adjusted to display fluid in the biliary tree and pancreatic ducts. MRI uses the noniodinated contrast medium gadopentetate dimeglumine (Magnevist), which is administered IV to enhance contrast differences between normal and abnormal tissues.

Magnetic resonance angiography (MRA) is an application of MRI that provides images of blood flow and diseased and normal blood vessels. In patients who are allergic to iodinated contrast medium, MRA is used in place of angiography (see monograph titled “Magnetic Resonance Angiography”).

INDICATIONS:

- Detect pancreatic fatty infiltration, hemorrhage, and adenopathy
- Detect a pancreatic mass
- Detect pancreatitis
- Detect primary or metastatic tumors of the pancreas and provide cancer staging

- Detect soft tissue abnormalities
- Determine vascular complications of pancreatitis, venous thrombosis, or pseudoaneurysm
- Differentiate tumors from other abnormalities, such as cysts, cavernous hemangiomas, and pancreatic abscesses
- Monitor and evaluate the effectiveness of medical or surgical interventions and course of disease

RESULT:

Normal findings in:

- Normal anatomic structures and soft tissue density and biochemical constituents of the pancreatic parenchyma, including blood flow

Abnormal findings in:

- Islet cell tumor
- Metastasis
- Pancreatic duct obstruction or calculi
- Pancreatic fatty infiltration, hemorrhage, and adenopathy
- Pancreatic mass
- Pancreatitis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with certain ferrous metal prostheses, valves, aneurysm clips, inner ear prostheses, or other metallic objects
- Patients with metal in their body, such as shrapnel or ferrous metal in the eye
- Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
- Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73m²).

Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.

- Patients with intrauterine devices
- Patients with iron pigments in tattoos
- Patients who are claustrophobic
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Patients with extreme cases of claustrophobia, unless sedation is given before the study or an open MRI is utilized

Other considerations:

- If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the pancreas and the organs and structures inside the abdomen.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of results of the patient's hepatobiliary and endocrine systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.
- ▶ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ▶ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no pain will be experienced during the test, but there may be moments of discomfort. Reassure the patient that if contrast is used, it poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in an MRI department by a health care provider (HCP) specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ Inform the patient that the technologist will place him or her in a supine position on a flat table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly

to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ Instruct the patient to remove jewelry and all other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images

are taken and then to exhale after the images are taken.

- ◆ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ◆ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ◆ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ◆ Instruct the patient in the care and assessment of the injection site.
- ◆ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.

- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include amylase, angiography of the abdomen, BUN, calcitonin, cholangiopancreatography endoscopic retrograde, CT abdomen, creatinine, hepatobiliary scan; 5-hydroxyindoleacetic acid, lipase, peritoneal fluid analysis, US liver and biliary system, and US pancreas.
- ◆ Refer to the Hepatobiliary and Endocrine System tables at the back of the book for related tests.

Magnetic Resonance Imaging, Pelvis

SYNONYM/ACRONYM: Pelvic MRI.

AREA OF APPLICATION: Pelvic area.

CONTRAST: Can be done with or without IV contrast medium (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. Use of magnetic fields with the aid of radiofrequency energy produces images primarily based on

water content of tissue. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned

off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of the pelvic area in multiple planes without the use of ionizing radiation or the interference of bone or surrounding tissue.

Pelvic MRI is performed to assist in diagnosing abnormalities of the pelvis and associated structures. Contrast-enhanced MRI is effective for evaluating metastases from primary tumors. MRI is highly effective for depicting small-volume peritoneal tumors, carcinomatosis, and peritonitis and for determining the response to surgical and chemical therapies. MRI uses the noniodinated contrast medium gadopentetate dimeglumine (Magnevist), which is administered IV to enhance contrast differences between normal and abnormal tissues. Oral and rectal contrast administration may be used to isolate the bowel from adjacent pelvic organs and improve organ visualization.

Magnetic resonance angiography (MRA) is an application of MRI that provides images of blood flow and diseased and normal blood vessels. In patients who are allergic to iodinated contrast medium, MRA is used in place of angiography (see monograph titled “Magnetic Resonance Angiography”).

INDICATIONS:

- Detect cancer (primary or metastatic tumors of ovary, prostate, uterus, and bladder) and provide cancer staging

- Detect pelvic vascular diseases
- Detect peritonitis
- Detect soft tissue abnormalities
- Determine blood clots, cysts, fluid or fat accumulation in tissues, hemorrhage, and infarctions
- Differentiate tumors from tissue abnormalities, such as cysts, cavernous hemangiomas, and abscesses
- Monitor and evaluate the effectiveness of medical or surgical interventions and course of the disease

RESULT:

Normal findings in:

- Normal pelvic structures and soft tissue density and biochemical constituents of pelvic tissues, including blood flow




Abnormal findings in:

- Adenomyosis
- Ascites
- Fibroids
- Masses, lesions, infections, or inflammations
- Peritoneal tumor or carcinomatosis
- Peritonitis
- Pseudomyxoma peritonei

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with certain ferrous metal prostheses, valves, aneurysm clips, inner ear prostheses, or other metallic objects
-  Patients with metal in their body, such as shrapnel or ferrous metal in the eye
-  Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
-  Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73m²).

Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.

- Patients with intrauterine devices
- Patients with iron pigments in tattoos
- Patients who are claustrophobic
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Patients with extreme cases of claustrophobia, unless sedation is given before the study or an open MRI is utilized

Other considerations:

- If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the organs and structures inside the pelvis and lower abdomen.
- ▶ Obtain a history of the patient's complaints, including a list of known

allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.

- ▶ Obtain a history of results of the patient's gastrointestinal and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.
- ▶ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ▶ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no pain will be experienced during the test, but there may be moments of discomfort. Reassure the patient that if contrast is used, it poses no radioactive hazard and rarely produces side effects. Inform the patient the procedure is performed in an MRI department by a health care provider (HCP) specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ Inform the patient that the technologist will place him or her in a supine position on a flat table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ Instruct the patient to remove jewelry and all other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images are taken and then to exhale after the images are taken.

- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include BUN, CT pelvis, creatinine, cystourethography voiding, IVP, KUB study, renogram, and US pelvis.
- ▶ Refer to the Gastrointestinal and Genitourinary System tables at the back of the book for related tests.

Magnetic Resonance Imaging, Pituitary

SYNONYM/ACRONYM: Pituitary MRI, MRI of the perisellar region.

AREA OF APPLICATION: Brain/pituitary area.

CONTRAST: Can be done with or without IV contrast medium (gadolinium).

DESCRIPTION: Magnetic resonance imaging (MRI) uses a magnet and radio waves to produce an energy field that can be displayed as an image. Use of magnetic fields with the aid of radiofrequency energy produces images primarily based on water content of tissue. The magnetic field causes the hydrogen atoms in tissue to line up, and when radio waves are directed toward the magnetic field, the atoms absorb the radio waves and change their position. When the radio waves are turned off, the atoms go back to their original position; this change in the energy field is sensed by the equipment, and an image is generated by the attached computer system. MRI produces cross-sectional images of the pituitary and perisellar region in multiple planes without the use of ionizing radiation or the interference of bone or surrounding tissue.

Pituitary MRI shows the relationship of pituitary lesions to the optic chiasm and cavernous sinuses. MRI has the capability of distinguishing the solid, cystic, and hemorrhagic components of lesions. Rapidly flowing blood on spin-echo MRI appears as an absence of signal or a void in the vessel's lumen. Blood flow can be evaluated in the

cavernous and carotid arteries. Suprasellar aneurysms may be diagnosed without angiography, and old clotted blood in the walls of the aneurysms appears white. MRI uses the noniodinated contrast medium gadopentetate dimeglumine (Magnevist), which is administered IV to enhance contrast differences between normal and abnormal tissues.

Magnetic resonance angiography (MRA) is an application of MRI that provides images of blood flow and diseased and normal blood vessels. In patients who are allergic to iodinated contrast medium, MRA is used in place of angiography (see monograph titled "Magnetic Resonance Angiography").

INDICATIONS:

- Detect microadenoma or macroadenoma of the pituitary
- Detect perisellar abnormalities
- Detect tumors of the pituitary
- Evaluate potential cause of headache, visual loss, and vomiting
- Evaluate the solid, cystic, and hemorrhagic components of lesions
- Evaluate vascularity of the pituitary
- Monitor and evaluate the effectiveness of medical or surgical interventions and course of disease




RESULT:**Normal findings in:**

- Normal anatomic structures, density, and biochemical constituents of the pituitary, including blood flow

Abnormal findings in:

- Abscess
- Aneurysm
- Choristoma
- Craniopharyngioma or meningioma
- Empty sella
- Granuloma
- Infarct or hemorrhage
- Macroadenoma or microadenoma
- Metastasis
- Parasitic infection

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

- Patients with certain ferrous metal prostheses, valves, aneurysm clips, inner ear prostheses, or other metallic objects
-  Patients with metal in their body, such as shrapnel or ferrous metal in the eye
-  Patients with cardiac pacemakers, because the pacemaker can be deactivated by MRI
-  Use of gadolinium-based contrast agents (GBCA) is contraindicated in patients with acute or chronic severe renal insufficiency (glomerular filtration rate less than 30 mL/min/1.73 m²). Patients should be screened for renal dysfunction prior to administration. The use of GBCAs should be avoided in these patients unless the benefits of the studies outweigh the risks and if essential diagnostic information is not available using non-contrast-enhanced diagnostic studies.
- Patients with intrauterine devices
- Patients with iron pigments in tattoos
- Patients who are claustrophobic

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Patients with extreme cases of claustrophobia, unless sedation is given before the study or an open MRI is utilized.

Other considerations:

- If contrast medium is allowed to seep deep into the muscle tissue, vascular visualization will be impossible.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses the pituitary and surrounding brain tissue.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ♦ Obtain a history of results of the patient's cardiovascular and endocrine systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of renal dysfunction if the use of GBCA is anticipated.

M

- ▶ Ensure the results of BUN, creatinine, and eGFR (estimated glomerular filtration rate) are obtained if GBCA is to be used.
- ▶ Determine if the patient has ever had any device implanted into his or her body, including copper intrauterine devices, pacemakers, ear implants, and heart valves.
- ▶ Obtain occupational history to determine the presence of metal in the body, such as shrapnel or flecks of ferrous metal in the eye (which can cause retinal hemorrhage).
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no pain will be experienced during the test, but there may be moments of discomfort. Inform the patient the procedure is performed in an MRI department by a health care provider (HCP) specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ Inform the patient that the technologist will place him or her in a supine position on a flat table in a large cylindrical scanner.
- ▶ Tell the patient to expect to hear loud banging from the scanner and possibly to see magnetophosphenes (flickering lights in the visual field); these will stop when the procedure is over.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives.
- ▶ Instruct the patient to remove jewelry and all other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Supply earplugs to the patient to block out the loud, banging sounds that occur during the test. Instruct the patient to communicate with the technologist during the examination via a microphone within the scanner.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in the supine position on an exam table.
- ▶ If contrast is used, imaging can begin shortly after the injection.
- ▶ Ask the patient to inhale deeply and hold his or her breathe while the images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.

- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
 - ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
 - ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
 - ▶ Instruct the patient in the care and assessment of the injection site.
 - ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
 - ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH and challenge tests, angiography brain, BUN, cortisol and challenge tests, CT brain, creatinine, EEG, MRI brain, and PET brain.
- ▶ Refer to the Cardiovascular and Endocrine System tables at the back of the book for related tests by body system.

Mammography

M

SYNONYM/ACRONYM: Mammogram, breast x-ray.

AREA OF APPLICATION: Breast.

CONTRAST: None.

DESCRIPTION: Mammography, an x-ray examination of the breast, is most commonly used to detect breast cancer; however, it can also be used to detect and evaluate symptomatic changes associated with other breast diseases, including mastitis, abscess, cystic changes, cysts, benign tumors, masses, and lymph nodes. Mammography is usually performed with traditional x-ray film, but totally electronic image recording is

becoming commonplace. Mammography can be used to locate a nonpalpable lesion for biopsy. Mammography cannot detect breast cancer with 100% accuracy. In approximately 15% of breast cancer cases, the cancer is not detected with mammography. To assist in early detection of nonpalpable breast lesions, computer-assisted diagnosis is currently being used. With this technique, a computer performs automated scanning of

the mammogram before the physician interprets the findings.

When a mass is detected, additional studies are performed to help differentiate the nature of the mass, as follows:

Magnification views of the area in question

Focal or “spot” views of the area in question, done with a specialized paddle-style compression device

Ultrasound images of the area in question, which help differentiate between a fluid-filled cystic lesion and a solid lesion indicative of cancer or fibroadenomas

The American College of Physicians recommends an annual or biannual mammogram for women age 50 and older. Their guidelines, based on evidence-based studies, recommend that women between 40 and 49 yr discuss their personal risk/benefit with a health care professional (HCP) prior to mammography. Scientific evidence studied in the preparation of these guidelines indicates that breast cancer risk is not distributed evenly among women in their 40s; therefore, uniform screening of women in this age group is not supported without consideration of family history and other risk factors.

The American Cancer Society recommends that all women follow a personal breast-care plan according to age:

Women ages 20 to 39: Clinical breast examination performed by a HCP every 3yr and a monthly breast self-examination

Women ages 40 and older: Annual mammogram, clinical breast examination every year by a HCP (near time of the mammogram), and monthly breast self-examination.

INDICATIONS:

- Differentiate between benign and neoplastic breast disease
- Evaluate breast pain, skin retraction, nipple erosion, or nipple discharge
- Evaluate known or suspected breast cancer
- Evaluate nonpalpable breast masses
- Evaluate opposite breast after mastectomy
- Monitor postoperative and post-radiation treatment status of the breast
- Evaluate size, shape, and position of breast masses

RESULT:

Normal findings in:

- Normal breast tissue, with no cysts, tumors, or calcifications

Abnormal findings in:

- Breast calcifications
- Breast cysts or abscesses
- Breast tumors
- Hematoma resulting from trauma
- Mastitis
- Soft-tissue masses
- Vascular calcification

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Patients younger than age 25, because the density of the breast tissue is such that diagnostic x-rays are of limited value

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Application of substances such as talcum powder, deodorant, or creams to the skin of breasts or underarms, which may alter test results
- Previous breast surgery, breast augmentation, or the presence of breast implants, which may decrease the readability of the examination

Other considerations:

- Consultation with a HCP should occur before the procedure for radiation safety concerns regarding infants of patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses breast status.
- ▶ Obtain a history of the patient's symptoms and complaints.
- ▶ Obtain a history of known or suspected breast disease, and family history of breast disease.
- ▶ Obtain a history of results of previously performed breast biopsies and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure. Inform the patient there may be discomfort associated with the study, while the breast is being compressed, but that the compression allows for better visualization of the breast tissue. Explain to the patient that the radiation dose will be kept to an absolute minimum. Inform the patient that the procedure is performed in the mammography department by a registered mammographer and takes approximately 15 to 30 min to complete.
- ▶ Inform the patient that the best time to schedule the examination is 1 wk after menses, when breast tenderness is decreased.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during and after the procedure.
- ▶ Inform the patient not to apply deodorant, body creams, or powders on the day of the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the field of examination.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all jewelry, and other metallic objects from the chest area.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown and robe provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions and follow the general guidelines in Appendix A.
- ▶ Assist the patient to a standing or sitting position in front of the x-ray machine, which is adjusted to the level of the breasts. Position the patient's arms out of the range of the area to be imaged.

- Place breasts, one at a time, between the compression apparatus. Two views or exposures are taken of each breast. Ask the patient to hold her breathe during each exposure. Additional images may be taken as requested by the radiologist before the patient leaves the mammography room.

POST-TEST:

- A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- Determine if the patient has any further questions or concerns.
- Educate the patient regarding the techniques for breast self-examination.
- Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Cancer Society (www.cancer.org).

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient. Instruct and educate the patient how to perform monthly breast self-examination and emphasize, as appropriate, the importance of having a mammogram performed as indicated through discussion with her HCP and in keeping with the current standard of care. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include biopsy breast, cancer antigens, MRI breast, stereotactic biopsy breast, and US breast.
- Refer to the Reproductive System table at the back of the book for related tests by body system.

M

Meckel's Diverticulum Scan

SYNONYM/ACRONYM: Meckel's scan, Meckel's scintigraphy, ectopic gastric mucosa scan.

AREA OF APPLICATION: Abdomen.

CONTRAST: IV radioactive technetium-99m pertechnetate.

DESCRIPTION: Meckel's diverticulum scan is a nuclear medicine study performed to assist in diagnosing the cause of abdominal pain or occult gastrointestinal (GI) bleeding, and to assess the presence and size of a

congenital anomaly of the GI tract. After IV injection of technetium-99m pertechnetate, immediate and delayed imaging is performed, with various views of the abdomen obtained. The radionuclide is taken up and

concentrated by parietal cells of the gastric mucosa, whether located in the stomach or in a Meckel's diverticulum. Up to 25% of Meckel's diverticulum is lined internally with ectopic gastric mucosal tissue. This tissue is usually located in the ileum and right lower quadrant of the abdomen; it secretes acid that causes ulceration of intestinal tissue, which results in abdominal pain and occult blood in stools.

INDICATIONS:

- Aid in the diagnosis of unexplained abdominal pain and GI bleeding caused by hydrochloric acid and pepsin secreted by ectopic gastric mucosa, which ulcerates nearby mucosa
- Detect sites of ectopic gastric mucosa

RESULT:

Normal findings in:

- Normal distribution of radionuclide by gastric mucosa at normal sites

Abnormal findings in:

- Meckel's diverticulum, as evidenced by focally increased radioactive uptake in areas other than normal structures

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure

because of age, significant pain, or mental status

- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Retained barium from a previous radiological procedure
- Other nuclear scans done within the preceding 24 hr

Other considerations:

- Improper injection of the radionuclide may allow the tracer to seep deep into the muscle tissue, producing erroneous hot spots.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- False-positive results may occur from nondiverticular bleeding, intussusception, duplication cysts, inflammatory bowel disease, hemangioma of the bowel, and other organ infections.
- Inadequate amount of gastric mucosa within Meckel's diverticulum can affect the ability to visualize abnormalities.
- Inaccurate timing for imaging after the radionuclide injection can affect the results.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

**NURSING IMPLICATIONS
AND PROCEDURE****PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses GI bleeding.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's cardiovascular and GI systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department by a HCP specializing in this procedure, with support staff, and takes approximately 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually normal saline is infused.
- ▶ Instruct the patient to remove jewelry other metallic objects from the area to be examined.
- ▶ Instruct the patient to take a histamine blocker, as ordered, 2 days before the study to block GI secretion.
- ▶ The patient should fast and refrain from fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in a supine position on a flat table with foam wedges, which help maintain position and immobilization.
- ▶ IV radionuclide is administered and the abdomen is scanned immediately to screen for vascular lesions. Images are taken in various positions every 5 min for the next hour.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

- Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- Instruct the patient to resume usual diet, fluids, and medications, as directed by the HCP.
- Monitor vital signs and neurological status every 15 minutes for 1 hour, then every 2 hr for 4 hr, and then as ordered by the HCP. Compare with baseline values. Protocols may vary from facility to facility.
- Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- Instruct the patient to immediately flush the toilet, and to meticulously

wash hands with soap and water after each voiding for 24 hr after the procedure.

- Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes. High fat consumption increases the amount of bile acids in the colon and should be avoided.
- Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include barium swallow, colonoscopy, CT abdomen, CT pelvis, esophageal manometry, EGD, fecal analysis, gastric acid stimulation, gastric emptying scan, gastrin stimulation, GI blood loss, MRI abdomen, MRI pelvis, and upper GI series.
- Refer to the Gastrointestinal and Cardiovascular System tables in the back of the book for related tests by body system.

Mediastinoscopy

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Mediastinum.

CONTRAST: None.

DESCRIPTION: Mediastinoscopy provides direct visualization of the structures that lie beneath the mediastinum, which is the area behind the sternum and between the lungs. The test is performed under general anesthesia by means of a mediastinoscope inserted through a surgical incision at the suprasternal notch. Structures that can be viewed include the trachea, the esophagus, the heart and its major vessels, the thymus gland, and the lymph nodes that receive drainage from the lungs. The procedure is performed primarily to visualize and obtain biopsy specimens of the mediastinal lymph nodes, and to determine the extent of metastasis into the mediastinum for the determination of treatment planning in cancer patients.

INDICATIONS:

- Confirm radiological evidence of a thoracic infectious process of an indeterminate nature, coccidioidomycosis, or histoplasmosis
- Confirm radiological or cytological evidence of carcinoma or sarcoidosis
- Detect Hodgkin's disease
- Detect metastasis into the anterior mediastinum or extrapleurally into the chest
- Determine stage of known bronchogenic carcinoma, as indicated

by the extent of mediastinal lymph node involvement

- Evaluate a patient with signs and symptoms of obstruction of mediastinal lymph flow and a history of head or neck cancer to determine recurrence or spread

RESULT:

Normal findings in:

- Normal appearance of mediastinal structures
- No abnormal lymph node tissue

Abnormal findings in:

- Bronchogenic carcinoma
- Coccidioidomycosis
- Granulomatous infections
- Histoplasmosis
- Hodgkin's disease
- *Pneumocystis carinii* infection
- Sarcoidosis
- Tuberculosis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who have had a previous mediastinoscopy, because scarring can make insertion of the scope and biopsy of lymph nodes difficult
- Patients who have superior vena cava obstruction, because this condition causes increased venous collateral circulation in the mediastinum
- Patients who are pregnant or suspected of being pregnant, unless

the potential benefits of the procedure far outweigh the risks to the fetus and mother

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient the procedure assesses the mediastinum.
- ▶ Obtain a history of the patient's complaints or symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, and anesthetics.
- ▶ Obtain a history of the patient's immune and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that the results of blood typing and cross-matching are obtained and recorded before the procedure in the event that an emergency thoracotomy is required.
- ▶ Note any recent procedures that can interfere with test results. Ensure that this procedure is performed before an upper gastrointestinal study or barium swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that prophylactic antibiotics may be administered prior to the procedure. Address concerns about pain related to the procedure and explain that a general anesthesia will be administered to promote relaxation and reduce discomfort prior to the mediastinoscopy. Explain to the

patient that some pain may be experienced after the test. Meperidine (Demerol) or morphine may be given as a sedative. Inform the patient that the procedure is performed in the operating room by a health care provider (HCP) specializing in this procedure, with support staff, and usually takes 30 to 60 min to complete.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, antibiotics, anesthetics, and analgesics.
- ▶ Instruct the patient to remove jewelry and external metallic objects from the area to be examined prior to the procedure.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with food, fluids, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure that the patient has removed jewelry and external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and change into the gown, robe, and foot coverings provided.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish IV fluid line for the injection of emergency drugs and of sedatives.

M

- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Avoid using morphine sulfate in patients with asthma or other pulmonary disease. This drug can further exacerbate bronchospasms and respiratory impairment.
- ▶ Place the patient in the supine position. General anesthesia is administered via an endotracheal tube.
- ▶ An incision is made at the suprasternal notch, and a path for the mediastinoscope is made using finger dissection. The lymph nodes can be palpated at this time. The lymph nodes on the right side of the mediastinum are most accessible and safest to biopsy by mediastinoscopy; the lymph nodes on the left side are more difficult to explore and biopsy because of their proximity to the aorta. Biopsy specimens of nodes on the left side of the mediastinum may need to be obtained by mediastinotomy, which involves performing a left anterior thoracotomy.
- ▶ Place tissue samples in properly labeled specimen containers, and promptly transport the specimen to the laboratory for processing and analysis.
- ▶ The scope is removed, and the incision is closed.
- ▶ If the patient is stable and if no further surgery is immediately indicated, the patient is extubated.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ The patient should remain in a semi-Fowler's position on either side until vital signs revert to preprocedure levels.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature changes. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Do not allow the patient to eat or drink for 12 to 24 hr.
- ▶ Instruct the patient to resume normal activity, medication, and diet in 24 hr or as tolerated after the examination, unless otherwise indicated.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Instruct the patient in the care and assessment of the site. Observe the site for bleeding, hematoma formation, and inflammation. Note any pleuritic pain, persistent right shoulder pain, or chest pain.
- ▶ Emphasize that any excessive bleeding, difficulty breathing, excessive coughing after biopsy, or pain must be reported to the HCP immediately.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACE, β_2 -microglobulin, biopsy liver, biopsy lung, biopsy lymph node, blood gases, bronchoscopy, carbon dioxide, chest x-ray, complete blood count, complete blood count, WBC count and differen-

tial, CT thoracic, culture and smear mycobacteria, gallium scan, gram stain, laparoscopy abdominal, LAP, liver and spleen scan, lung perfusion scan, lung ventilation scan, lymphangiogram, MRI

chest, platelet count, pleural fluid analysis, PFT, and TB skin tests.
 ▶ Refer to the Immune and Respiratory System tables in the back of the book for related tests by body system.

Metanephrines

SYNONYM/ACRONYM: N/A.

SPECIMEN: Urine (25 mL) from a timed specimen collected in a clean amber plastic collection container with 6N hydrochloride as a preservative.

REFERENCE VALUE: (Method: High-pressure liquid chromatography)

Age	Conventional Units	SI Units
Normetanephrines (Conventional Units × 5.46)		
0–3 mo	47–156 mcg/24 hr	257–852 nmol/24 hr
4–6 mo	31–111 mcg/24 hr	171–607 nmol/24 hr
7–9 mo	42–109 mcg/24 hr	230–595 nmol/24 hr
10–12 mo	23–103 mcg/24 hr	127–562 nmol/24 hr
1–2 yr	32–118 mcg/24 hr	175–647 nmol/24 hr
2–6 yr	50–111 mcg/24 hr	274–604 nmol/24 hr
6–10 yr	47–176 mcg/24 hr	255–964 nmol/24 hr
10–16 yr	53–290 mcg/24 hr	289–1586 nmol/24 hr
Adult	82–500 mcg/24 hr	448–2730 nmol/24 hr
Metanephrines (Conventional Units × 5.07)		
0–3 mo	5.9–37 mcg/24 hr	30–188 nmol/24 hr
4–6 mo	6.1–42 mcg/24 hr	31–213 nmol/24 hr
7–9 mo	12–41 mcg/24 hr	61–210 nmol/24 hr
10–12 mo	8.5–101 mcg/24 hr	43–510 nmol/24 hr
1–2 yr	6.7–52 mcg/24 hr	34–264 nmol/24 hr
2–6 yr	11–99 mcg/24 hr	56–501 nmol/24 hr
6–10 yr	54–138 mcg/24 hr	275–701 nmol/24 hr
10–16 yr	39–243 mcg/24 hr	200–1231 nmol/24 hr
Adult	45–290 mcg/24 hr	228–1470 nmol/24 hr

DESCRIPTION: Metanephrines are the inactive metabolites of epinephrine and norepinephrine. Metanephrines are either excreted

or further metabolized into vanillylmandelic acid. Release of metanephrines in the urine is indicative of disorders

associated with excessive catecholamine production, particularly pheochromocytoma. Vanillyl-mandelic acid and catecholamines are normally measured with urinary metanephrines. Creatinine is usually measured simultaneously to ensure adequate collection and to calculate an excretion ratio of metabolite to creatinine.

INDICATIONS:

- Assist in the diagnosis of suspected pheochromocytoma
- Assist in identifying the cause of hypertension
- Verify suspected tumors associated with excessive catecholamine secretion

RESULT:

Increased in:

- Ganglioneuroma
- Neuroblastoma
- Pheochromocytoma
- Severe stress

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase metanephrine levels include labetalol, monoamine oxidase inhibitors, oxprenolol, oxytetracycline, and prochlorperazine.
- Methylglucamine in x-ray contrast medium may cause false-negative results.
- All urine voided for the timed collection period must be included in the collection or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of pheochromocytoma, neuroblastoma, and ganglioblastoma.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ♦ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ♦ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ♦ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may

have been discarded, thus invalidating the test.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to avoid excessive exercise and stress during the 24-hr collection of urine.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with activity restrictions during the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically

during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.

- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- ▶ Include on the collection container's label the amount of urine and test start and stop times.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual activity, as directed by the HCP.
- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography adrenal, CEA, catecholamines, CT renal, HVA, renin, and VMA.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Methemoglobin

SYNONYM/ACRONYM: Hemoglobin, hemoglobin M, MetHb, Hgb M.

SPECIMEN: Whole blood (1 mL) collected in green-top (heparin) tube. Specimen should be transported tightly capped and in an ice slurry.

REFERENCE VALUE: (Method: Spectrophotometry)

Conventional Units	SI Units (Conventional Units × 155)
0.06–0.24 g/dL*	9.3–37.2 micromol/L*

*Percentage of total hemoglobin = 0.41–1.15%.

Note: The conversion factor of X155 is based on the molecular weight of hemoglobin of 64,500 daltons (d), or 64.5 kd.

DESCRIPTION: Methemoglobin is a structural hemoglobin variant formed when the heme portion of the deoxygenated hemoglobin is oxidized to a ferric state that renders it incapable of combining with and transporting oxygen to tissues. Visible cyanosis can result as levels approach 10% to 15% of total hemoglobin.

INDICATIONS:

- Assist in the detection of acquired methemoglobinemia caused by the toxic effects of chemicals and drugs
- Assist in the detection of congenital methemoglobinemia, indicated by deficiency of red blood cell nicotinamide adenine dinucleotide (NADH)-methemoglobin reductase or presence of methemoglobin.
- Evaluate cyanosis in the presence of normal blood gases

RESULT:

Increased in:

- Acquired methemoglobinemia (drugs, tobacco smoking, or ionizing radiation)

- Carbon monoxide poisoning (*Carbon monoxide is a form of deoxygenated hemoglobin*)
- Hereditary methemoglobinemia (*Deficiency of NADH-methemoglobin reductase or hemoglobinopathy*)

Decreased in: N/A

CRITICAL VALUES:

Cyanosis can occur at levels greater than 10%.

Dizziness, fatigue, headache, and tachycardia can occur at levels greater than 30%.

Signs of central nervous system depression can occur at levels greater than 45%.

Death may occur at levels greater than 70%.

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms. Possible interventions include airway protection, administration of oxygen, monitoring neurological status every hour, continuous pulse oximetry, hyperbaric oxygen therapy, and exchange transfusion. Administration of activated charcoal or gastric lavage

may be effective if performed soon after the toxic agent is ingested. Emesis should never be induced in patients with no gag reflex because of the risk of aspiration. Methylene blue may be used to reverse the process of methemoglobin formation, but it should be used cautiously when methemoglobin levels are greater than 30%. Use of methylene blue is contraindicated in the presence of glucose-6-phosphate dehydrogenase deficiency.

INTERFERING FACTORS:

- Drugs that may increase methemoglobin levels include acetanilid, amyl nitrate, aniline derivatives, benzocaine, chlorates, chloroquine, dapson, glucosulfone, isoniazid, lidocaine, nitroglycerin, phenacetin, phenytoin, primaquine, resorcinol, sulfonamides, and thiazolsulfone.
- Well water containing nitrate is the most common cause of methemoglobinemia in infants.
- Breastfeeding infants are capable of converting inorganic nitrate from common topical anesthetic applications containing nitrate to the nitrite ion, causing nitrite toxicity and increased methemoglobin.
- Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results. Methemoglobin is unstable and should be transported on ice within a few hours of collection, or else the specimen should be rejected.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to investigate cyanosis associated with

polycythemia, hemoglobinopathies, and drug toxicity (inhaled substances).

- ▶ Obtain a history of the patient's complaints, including a list of known allergies, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ Prepare an ice slurry in a cup or plastic bag to have on hand for immediate transport of the specimen to the laboratory.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

M

The specimen should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Teach the patient to avoid carbon monoxide from first- or second-hand smoking, to have home gas furnace checked yearly for leaks, and to utilize gas appliances such as gas grills in a well-ventilated area.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.

Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include alveolar/arterial gradient, blood gases, carboxyhemoglobin, hemoglobin electrophoresis, and pulse oximetry.
- ▶ Refer to the Hematopoietic and Respiratory System tables at the back of the book for related tests by body system.

Microalbumin

SYNONYM/ACRONYM: Albumin, urine.

SPECIMEN: Urine (10 mL) from a random or timed specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Nephelometry immunoassay)

Test	Conventional Units
Random microalbumin	Less than 0.03 mg albumin/mg creatinine
24-hr microalbumin	
<i>Normal</i>	Less than 30 mg/24h
<i>Microalbuminuria</i>	30–299 mg/24h
<i>Clinical Albuminuria</i>	300 mg or greater/24h

Simultaneous measurement of urine creatinine or creatinine clearance may be requested. Normal ratio of microalbumin to creatinine is less than 30:1.

DESCRIPTION: The term *microalbumin* is used to describe concentrations of albumin in urine that are greater than normal but undetectable by dipstick

or traditional spectrophotometry methods. Microalbuminuria precedes the nephropathy associated with diabetes and is often elevated years before creatinine

clearance shows abnormal values. Studies have shown that the median duration from onset of microalbuminuria to development of nephropathy is 5 to 7 yr.

INDICATIONS:

- Evaluate renal disease
- Screen diabetic patients for early signs of nephropathy

RESULT:

Increased in:
Conditions resulting in increased renal excretion or loss of protein.

- Cardiomyopathy
- Diabetic nephropathy
- Exercise
- Hypertension (uncontrolled)
- Pre-eclampsia
- Renal disease
- Urinary tract infections

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may decrease microalbumin levels include captopril, dipyridamole, enalapril, furosemide, indapamide, perindopril, quinapril, ramipril, tolrestat, and triflusal.
- All urine voided for the timed collection period must be included in the collection or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to assist in the management of early diabetes in order to avoid or delay the onset of renal disease associated with diabetes.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and genitourinary systems, symptoms, and results of previously performed laboratory tests, diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ Usually a 24-hour time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hour period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to avoid excessive exercise and stress during the 24-hour collection of urine.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with activity restrictions during the procedure.

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 minutes before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.

- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- ▶ Include on the collection container's label the amount of urine and test start and stop times.

General:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP) who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual activity, as directed by the HCP.
- ▶ Instruct the patient and caregiver to report signs and symptoms of hypoglycemia or hyperglycemia.
- ▶ **Nutritional considerations:** Instruct the patient, as appropriate, in nutritional management of diabetes. Patients who adhere to dietary recommendations report a better general feeling of health, better weight management, greater control of glucose and lipid values, and improved use of insulin. There is no "diabetic diet"; however, there are many meal-planning approaches with nutritional goals endorsed by the American Dietetic Association. The nutritional needs of each diabetic patient need to be determined individually with the appropriate health care professionals, particularly professionals trained in nutrition.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching

and information regarding the clinical implications of the test results, as appropriate. Emphasize, if indicated, that good glycemic control delays the onset and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. Educate the patient regarding access to counseling services, as appropriate. Provide contact information, if desired, for the American Diabetes Association (www.diabetes.org).

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in

therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include A/G ratio, angiography renal, blood pool imaging, BUN, complete blood count, cortisol, creatinine, creatinine clearance, culture urine, cystometry, cystoscopy, cytology urine, echocardiography, echocardiography transesophageal, EPO, fluorescein angiography, fundus photography, glucose, GTT, glycated hemoglobin, gonioscopy, holter monitor, insulin, insulin antibodies, magnesium, protein total and fractions, renogram, UA, visual fields test, and voiding cystourethrography.
- ◆ Refer to the Endocrine and Genitourinary System tables at the back of the book for related tests by body system.

β_2 -Microglobulin

SYNONYM/ACRONYM: β_2 -M, BMG.

SPECIMEN: Serum (1 mL) collected in a red-top tube or 5 mL urine from a timed collection in a clean plastic container with 1N NaOH as a preservative.

REFERENCE VALUE: (Method: Immunoassay for serum sample, radioimmunoassay for urine sample)

Sample	Conventional Units	SI Units (Conventional Units \times 10)
Serum		
Newborn	Less than 0.3 mg/dL	Less than 3 mg/L
Adult	Less than 0.2 mg/dL	Less than 2 mg/L
Urine	0.03–0.37 mg/24 h	

DESCRIPTION: β_2 -Microglobulin (BMG) is an amino acid peptide component of human leukocyte antigen (HLA) complexes. BMG increases in inflammatory

conditions and when lymphocyte turnover increases, such as in lymphocytic leukemia or when T-lymphocyte helper (OKT4) cells are attacked by

HIV. Serum BMG becomes elevated with malfunctioning glomeruli, but decreases with malfunctioning tubules because it is metabolized by the renal tubules. Conversely, urine BMG decreases with malfunctioning glomeruli, but becomes elevated with malfunctioning tubules.

INDICATIONS:

- Detect aminoglycoside toxicity
- Detect chronic lymphocytic leukemia, multiple myeloma, lung cancer, hepatoma, or breast cancer
- Detect HIV infection (note: levels do not correlate with stages of infection)
- Evaluate renal disease to differentiate glomerular from tubular dysfunction
- Monitor antiretroviral therapy

RESULT:

Increased in:

- AIDS (*Related to increased lymphocyte turnover*)
- Aminoglycoside toxicity (*Urine BMG becomes elevated before creatinine indicates renal damage*)
- Amyloidosis (*Chronic inflammatory conditions are associated with increased BMG and other acute phase reactant proteins*)
- Autoimmune disorders (*Related to increased lymphocyte turnover*)
- Breast cancer (*Related to increased lymphocyte turnover; serum BMG indicates tumor growth rate, size, and response to treatment*)
- Crohn's disease (*Chronic inflammatory conditions are associated with increased BMG and other acute phase reactant proteins*)
- Felty's syndrome (*Chronic inflammatory conditions are associated*

with increased BMG and other acute phase reactant proteins)

- Hepatitis (*Related to increased lymphocyte turnover in response to viral infection*)
- Hepatoma (*Related to increased lymphocyte turnover; serum BMG indicates tumor growth rate, size, and response to treatment*)
- Hyperthyroidism (*Related to increased lymphocyte turnover in immune thyroid disease*)
- Leukemia (chronic lymphocytic) (*Related to increased lymphocyte turnover; serum BMG indicates tumor growth rate, size, and response to treatment*)
- Lung cancer (*Related to increased lymphocyte turnover; serum BMG indicates tumor growth rate, size, and response to treatment*)
- Lymphoma (*Related to increased lymphocyte turnover; serum BMG indicates tumor growth rate, size, and response to treatment*)
- Multiple myeloma (*Related to increased lymphocyte turnover*)
- Poisoning with heavy metals, such as mercury or cadmium (*Related to renal damage that decreases BMG absorption*)
- Renal dialysis (*Related to ability of renal tubule to reabsorb BMG*)
- Renal disease (glomerular): serum only (*Related to ability of renal tubule to reabsorb BMG*)
- Renal disease (tubular): urine only (*Related to ability of renal tubule to reabsorb BMG*)
- Sarcoidosis
- Systemic lupus erythematosus (*Chronic inflammatory conditions are associated with increased BMG and other acute phase reactant proteins*)

- Vasculitis (**Chronic inflammatory conditions are associated with increased BMG and other acute phase reactant proteins**)
- Viral infections (e.g., cytomegalovirus) (**Related to increased lymphocyte turnover**)

Decreased in:

- Renal disease (glomerular): urine only
- Renal disease (tubular): serum only
- Response to zidovudine (AZT) (**Related to decreased viral replication and lymphocyte destruction**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and proteins that may increase serum BMG levels include cefuroxime, cyclosporin A, gentamicin, interferon alfa, pentoxifylline, and tumor necrosis factor.
- Drugs that may decrease serum BMG levels include zidovudine.
- Drugs that may increase urine BMG levels include azathioprine, cisplatin, cyclosporin A, furosemide, gentamicin, mannitol, nifedipine, sisomicin, and tobramycin.
- Drugs that may decrease urine BMG levels include cilostazol.
- Urinary BMG is unstable at pH less than 5.5.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- Inform the patient that the test is used to evaluate renal disease, AIDS, and certain malignancies.
- Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- Obtain a history of the patient's genitourinary and immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- Note any recent procedures that can interfere with test results.
- Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- There are no food, fluid, or medication restrictions, unless by medical direction.

Blood:

- Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

Urine:

- Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device.
- Usually a 24-hr urine collection is ordered. Inform the patient that all urine over a 24-hr period must be saved; instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom as a reminder to save all urine.
- Instruct the patient to void all urine into the collection device and then pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.

INTRATEST:

- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to

avoid unnecessary movement during the venipuncture.

- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes or collection containers with the corresponding patient demographics, date, and time of collection.

Blood:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Perform a venipuncture.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

Urine:

- Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- If possible, begin the test between 6 and 8 a.m. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. At the same time the next morning, ask the patient to void and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection started.
- At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection. If the specimen contains less than what was recorded as output, some urine may have been discarded, thus invalidating the test.

Blood or Urine:

- Promptly transport the specimen to the laboratory for processing and analysis. Include on the urine specimen label the amount of urine and ingestion of any medications that can affect test results.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Educate the patient regarding the risk of infection related to immunosuppressed inflammatory response and fatigue related to decreased energy production.
- Nutritional considerations:** Stress the importance of good nutrition, and suggest that the patient meet with a nutritional specialist. Also, stress the importance of following the care plan for medications and follow-up visits.
- Social and cultural considerations:** Recognize anxiety related to test results, and be supportive of impaired activity related to weakness, perceived loss of independence, and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for AIDS information provided by the National Institutes of Health (www.aidsinfo.nih.gov).
- Social and cultural considerations:** Counsel the patient, as appropriate, regarding risk of transmission and proper prophylaxis, and reinforce the importance of strict adherence to the treatment regimen.
- Social and cultural considerations:** Offer support, as appropriate, to patients who may be the victims of rape or sexual assault. Educate the patient regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for a discussion during which risks of sexually transmitted diseases are explained. It is also important to discuss problems the patient may experience (e.g., guilt, depression, anger).

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that retesting may be necessary. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include antibiotic drugs, ANA, barium enema, biopsy bone marrow, biopsy breast, biopsy liver, biopsy

lung, biopsy lymph node, BUN, capsule endoscopy, CD4/CD8 enumeration, colonoscopy, CRP, CEA and cancer antigens, complete blood count, creatinine, cultures (mycobacteria, sputum, viral), cytology sputum, CMV, ESR, gallium scan, GGT, hepatitis antigens and antibodies (A, B, C), HIV-1/HIV-2 serology, immunofixation electrophoresis, immunoglobulins A, G, and M, liver and spleen scan, lymphangiogram, MRI breast, mammogram, microalbumin, osmolality, protein total and fractions, renogram, RF, stereotactic breast biopsy, TB tests, US (breast, liver, lymph node), and UA.

- ◆ Refer to the Genitourinary and Immune System tables at the back of the book for related tests by body system.

Mumps Serology

M

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect immunofluorescence) Negative or less than a fourfold increase in titer.

DESCRIPTION: Mumps serology is done to determine the presence of mumps antibody, indicating exposure to or active presence of mumps. Mumps, also known as *parotitis*, is an infectious viral disease of the parotid glands caused by a myxovirus that is transmitted by direct contact with or droplets spread from the saliva of an infected person. The incubation period averages 3 weeks. Virus can be shed in

saliva for 2 weeks after infection and in urine for 2 weeks after the onset of symptoms. Complications of infection include aseptic meningitis, encephalitis, and inflammation of the testes, ovaries, and pancreas. The presence of immunoglobulin M (IgM) antibodies indicates acute infection. The presence of immunoglobulin G (IgG) antibodies indicates current or past infection.

INDICATIONS:

- Determine resistance to or protection against the mumps virus by a positive reaction, or susceptibility to mumps by a negative reaction
- Document immunity
- Evaluate mumps-like diseases and differentiate between these and actual mumps

RESULT:

- **Past or current mumps infection.**

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to confirm acute infection with or immunity to the mumps virus.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex. Obtain a history of exposure.
- ▶ Obtain a history of the patient's immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that several tests may be necessary to confirm diagnosis. Any individual positive result should be repeated in 7 to 14 days to monitor a change in titer. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient in isolation precautions during the time of communicability or contagion.
- ▶ Emphasize that the patient must return to have a convalescent blood sample taken in 7 to 14 days.
- ▶ Inform the patient that the presence of mumps antibodies ensures lifelong immunity.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Provide information regarding vaccine-preventable diseases where indicated (e.g., encephalitis, Hepatitis A and B, human papillomavirus, influenza, measles, mumps, polio, rubella, smallpox, varicella, yellow fever). Answer any

questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change

in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Refer to the Immune System table for related tests by body system.

Myocardial Infarct Scan

SYNONYM/ACRONYM: PYP cardiac scan, infarct scan, pyrophosphate cardiac scan, acute myocardial infarction scan.

AREA OF APPLICATION: Heart, chest/thorax.

CONTRAST: IV radioactive material, usually technetium-99m stannous pyrophosphate (PYP).

DESCRIPTION: Technetium-99m stannous pyrophosphate (PYP) scanning, also known as *myocardial infarct imaging*, reveals the presence of myocardial perfusion and the extent of myocardial infarction (MI). This procedure can distinguish new from old infarcts when a patient has had abnormal electrocardiograms (ECGs) and cardiac enzymes have returned to normal. PYP uptake by acutely infarcted tissue may be related to the influx of calcium through damaged cell membranes, which accompanies myocardial necrosis; that is, the radionuclide may be binding to calcium phosphates or to hydroxyapatite. The PYP in these damaged cells can be viewed as spots of increased radionuclide uptake that appear in 12 hr at the earliest.

PYP uptake usually takes place 24 to 72 hr after MI, and the

radionuclide remains detectable for approximately 10 to 14 days after the MI. PYP uptake is proportional to the blood flow to the affected area; with large areas of necrosis, PYP uptake may be maximal around the periphery of a necrotic area, with little uptake being detectable in the poorly perfused center. Most of the PYP is concentrated in regions that have 20% to 40% of the normal blood flow.

Single-photon emission computed tomography (SPECT) can be used to visualize the heart from multiple angles and planes, enabling areas of MI to be viewed with greater accuracy and resolution. This technique removes overlying structures that may confuse interpretation of the results. With the availability of assays of troponins, myocardial infarct imaging has become less important in the diagnosis of acute MI.

INDICATIONS:

- Aid in the diagnosis of (or confirm and locate) acute MI when ECG and enzyme testing do not provide a diagnosis
- Aid in the diagnosis of perioperative MI
- Differentiate between a new and old infarction
- Evaluate possible reinfarction or extension of the infarct
- Obtain baseline information about infarction before cardiac surgery

RESULT:**Normal findings in:**

- Normal coronary blood flow and tissue perfusion, with no PYP localization in the myocardium
- No uptake above background activity in the myocardium (*note:* when PYP uptake is present, it is graded in relation to adjacent rib activity)

Abnormal findings in:

- MI, indicated by increased PYP uptake in the myocardium

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risk of radiation exposure to the fetus
- Patients with hypersensitivity to the radionuclide

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

- Other nuclear scans done within the previous 24 to 48 hr
- Conditions such as chest wall trauma, cardiac trauma, or recent cardioversion procedure
- Myocarditis
- Pericarditis
- Left ventricular aneurysm
- Metastasis
- Valvular and coronary artery calcifications
- Cardiac neoplasms
- Aneurysms

Other considerations:

- Improper injection of the radionuclide may allow the tracer to seep deep into the muscle tissue, producing erroneous hot spots.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses blood flow to the heart.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed

laboratory tests and diagnostic and surgical procedures.

- ▶ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the medications the patient is taking, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department by a HCP specializing in this procedure, with support staff, and will take approximately 30–60 minutes. Inform the patient that the technologist will administer an IV injection of the radionuclide and that he or she will need to return 2 to 3 hr later for the scan.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ The patient should fast, restrict fluids, and refrain from smoking for 4 hr prior to the procedure. Instruct the patient to withhold medications for 24 hr before the procedure. Protocols may vary from facility to facility.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions and other pretesting preparations.
- ▶ Ensure that the patient has removed all external metallic objects prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.

- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to lie very still during the procedure because movement will produce unclear images.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in a supine position on a flat table with foam wedges to help maintain position and immobilization.
- ▶ IV radionuclide is administered. The heart is scanned 2 to 4 hr after injection in various positions. In most circumstances, however, SPECT is done so that the heart can be viewed from multiple angles and planes.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Evaluate the patient's vital signs. Monitor vital signs and neurological status every 15 min for one hr, then every 2 hr for 4 hr, and then as ordered by HCP. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Instruct the patient to resume normal activity and diet as directed by the HCP.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

- ▶ Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- ▶ If the patient must return for additional imaging, advise the patient to rest in the interim and restrict diet to liquids before redistribution studies.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to flush the toilet immediately after each voiding following the procedure, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography abdominal, AST, BNP, blood pool imaging, chest x-ray, CT abdominal, CT thoracic, CK and isoenzymes, culture viral, echocardiography, echocardiography transesophageal, ECG, MRA, MRI chest, myocardial perfusion scan, pericardial fluid analysis, and PET heart.
- ▶ Refer to the Cardiovascular System table at the back of the book for related tests by body system.

M

Myocardial Perfusion Heart Scan

SYNONYM/ACRONYM: Thallium scan, sestamibi scan, stress thallium.

AREA OF APPLICATION: Heart, chest/thorax.

CONTRAST: IV contrast medium.

DESCRIPTION: Cardiac scanning is a nuclear medicine study that reveals clinical information about coronary blood flow, ventricular size, and cardiac function. Thallium-201 chloride

rest or stress studies are used to evaluate myocardial blood flow to assist in diagnosing or determining the risk for ischemic cardiac disease, coronary artery disease (CAD), and myocardial

infarction (MI). This procedure is an alternative to angiography or cardiac catheterization in cases in which these procedures may pose a risk to the patient.

Thallium-201 is a potassium analogue and is taken up by myocardial cells proportional to blood flow to the cell and cell viability. During stress studies, the radionuclide is injected at peak exercise, after which the patient continues to exercise for several minutes. During exercise, areas of heart muscle supplied by normal arteries increase their blood supply, as well as the supply of thallium-201 delivery to the heart muscle, to a greater extent than regions of the heart muscle supplied by stenosed coronary arteries. This discrepancy in blood flow becomes apparent and quantifiable in subsequent imaging. Comparison of early stress images with images taken after 3 to 4 hr redistribution (delayed images) enables differentiation between normally perfused, healthy myocardium (which is normal at rest but ischemic on stress) and infarcted myocardium.

Technetium-99m agents such as sestamibi (2-methoxyisobutylisonitrile) are delivered similarly to thallium-201 during myocardial perfusion imaging, but they are extracted to a lesser degree on the first pass through the heart and are taken up by the mitochondria. Over a short period, the radionuclide concentrates in the heart to the same degree as thallium-201. The advantage to technetium-99m agents is that immediate imaging is unnecessary because the radionuclide remains fixed to the heart muscle for several hours. The examination requires two separate injections, one for the rest portion and one for the

stress portion of the procedure. These injections can take place on the same day or preferably over a 2-day period. Examination quality is improved if the patient is given a light, fatty meal after the radionuclide is injected to facilitate hepatobiliary clearance of the radioactivity.

If stress testing cannot be performed by exercising, dipyridamole (Persantine) or adenosine, a vasodilator, can be administered orally or IV. A coronary vasodilator is administered before the thallium-201, or other radionuclide, and the scanning procedure is then performed. Vasodilators increase blood flow in normal coronary arteries twofold to threefold without exercise, and they reveal perfusion defects when blood flow is compromised by vessel pathology. Vasodilator-mediated myocardial perfusion scanning is reserved for patients who are unable to participate in treadmill, bicycle, or handgrip exercises for stress testing because of lung disease, neurological disorders (e.g., multiple sclerosis, spinal cord injury), morbid obesity, and orthopedic disorders (e.g., arthritis, limb amputation).

Single-photon emission computed tomography can be used to visualize the heart from multiple angles and planes, enabling areas of MI to be viewed with greater accuracy and resolution. This technique removes overlying structures that may confuse interpretation of the results.

INDICATIONS:

- Aid in the diagnosis of CAD or risk for CAD
- Determine rest defects and reperfusion with delayed imaging in unstable angina

- Evaluate the extent of CAD and determine cardiac function
- Assess the function of collateral coronary arteries
- Evaluate bypass graft patency and general cardiac status after surgery
- Evaluate the site of an old MI to determine obstruction to cardiac muscle perfusion
- Evaluate the effectiveness of medication regimen and balloon angioplasty procedure on narrow coronary arteries
- Patients with left ventricular hypertrophy, right and left bundle branch block, hypokalemia, and patients receiving cardiotoxic therapy
- Patients with anginal pain at rest or patients with severe atherosclerotic coronary vessels, in whom dipyridamole testing cannot be performed
- Patients with asthma, because chemical stress with vasodilators can cause bronchospasms


RESULT:**Normal findings in:**

- Normal wall motion, coronary blood flow, tissue perfusion, and ventricular size and function

Abnormal findings in:

- Abnormal stress and resting images, indicating previous MI
- Abnormal stress images with normal resting images, indicating transient ischemia
- Cardiac hypertrophy, indicated by increased radionuclide uptake in the myocardium
- Enlarged left ventricle
- Heart chamber disorder
- Ventricular septal defects

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

-  Patients who have taken sildenafil (Viagra) within the previous 48 hr, as this test may require the use of nitrates (nitroglycerin) that can precipitate life-threatening low blood pressure
- Patients with bleeding disorders
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risk of radiation exposure to the fetus
- Patients with hypersensitivity to the radionuclide
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Medications such as digitalis and quinidine, which can alter cardiac contractility; and nitrates, which can affect cardiac performance
- Single-vessel disease, which can produce false-negative thallium-201 scanning results
- Conditions such as chest wall or cardiac trauma, angina that is difficult to control, significant cardiac arrhythmias, and recent cardioversion procedure
- Suboptimal cardiac stress or patient exhaustion preventing maximum heart rate testing
- Excessive eating or exercising between initial and redistribution imaging 4 hr later, which produces false-positive results
- Improper adjustment of the radiological equipment to accommodate obese or thin patients, which can cause overexposure or underexposure and a poor-quality study
- Patients who are very obese, or who may exceed the weight limit for the equipment
- Incorrect positioning of the patient, which may produce poor visualization of the area to be examined
- Metallic objects (e.g., jewelry, body rings) within the examination field,

Factors that may impair clear imaging:

which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Improper injection of the radionuclide that allows the tracer to seep deep into the muscle tissue produces erroneous hot spots.
- Inaccurate timing for imaging after radionuclide injection can affect the results.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to reveal their level of exposure to radiation.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses blood flow to the heart.
- ▶ Obtain a history of the patient's complaints and symptoms, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular system, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that some pain may be experienced during the test, or there may be moments of discomfort. Inform the patient that the procedure is performed in a special department, usually in a radiology or vascular suite, by a HCP specializing in this procedure and support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, dye, or sedatives. Usually normal saline is infused.
- ▶ Instruct the patient to wear walking shoes (if treadmill exercise testing is to be performed), and emphasize the importance of reporting fatigue, pain, or shortness of breathe.
- ▶ Instruct the patient to remove dentures, jewelry, and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to fast for 4 hr, refrain from smoking for 4 to 6 hr, and withhold medications for 24 hr before the test. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, tobacco, and medication restrictions and other pretesting preparations for 4 to 6 hr prior to the procedure.

- ▶ Ensure that the patient has removed external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Instruct the patient to void prior to the procedure and change into the gown, robe, and foot coverings provided.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Place electrocardiographic (ECG) electrodes on the patient for cardiac monitoring. Establish baseline rhythm; determine if the patient has ventricular arrhythmias. Monitor the patient's blood pressure throughout the procedure by using an automated blood pressure machine.
- ▶ Assist the patient onto the treadmill or bicycle ergometer and ask the patient to exercise to a calculated 80% to 85% of the maximum heart rate, as determined by the protocol selected.
- ▶ Wear gloves during the radionuclide injection and while handling the patient's urine.
- ▶ Thallium-201 is injected 60 to 90 sec before exercise is terminated, and imaging is done immediately in the supine position and repeated in 4 hr.
- ▶ Patients who cannot exercise are given dipyridamole 4 min before thallium-201 is injected.
- ▶ Inform the patient that movement during the resting procedure affects the results and makes interpretation difficult.
- ▶ The results are recorded on film or in a computerized system for recall and postprocedure interpretation by the appropriate HCP.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Evaluate the patient's vital signs. Monitor vital signs and neurological status every 15 min for one hr, then every 2 hr for 4 hr, and then as ordered by HCP. Compare with baseline values. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Instruct the patient to resume normal diet and activity, as directed by the HCP.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.
- ▶ If the patient must return for additional imaging, advise the patient to rest in the interim and restrict diet to liquids before redistribution studies.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to flush the toilet immediately after each voiding following the procedure, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.

- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, atrial natriuretic peptide, BNP, calcium, cholesterol (total, HDL, LDL), CT cardiac scoring, CRP, CK and isoenzymes, echocardiography, echocardiography transesophageal, ECG, exercise stress test, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isos, lipoprotein electrophoresis, magnesium, MRI chest, MI infarct scan, myoglobin, PET heart, potassium, triglycerides, and troponin.
- ▶ Refer to the Cardiovascular System table at the back of the book for related tests by body system.

Myoglobin

SYNONYM/ACRONYM: MB.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Nephelometry)

Conventional & SI Units

5–70 mcg/L

DESCRIPTION: Myoglobin is an oxygen-binding muscle protein normally found in skeletal and cardiac muscle. It is released

into the bloodstream after muscle damage from ischemia, trauma, or inflammation. Although myoglobin testing is more sensitive than creatinine kinase and isoenzymes, it does not indicate the specific site involved.

Timing for Appearance and Resolution of Serum/Plasma Cardiac Markers in AMI

Cardiac Marker	Appearance (Hours)	Peak (Hours)	Resolution (Days)
AST	6–8	24–48	3–4
CK (Total)	4–6	24	2–3
CK-MB	4–6	15–20	2–3
LDH	12	24–48	10–14
Myoglobin	1–3	4–12	1
Troponin I	2–6	15–20	5–7

INDICATIONS:

- Assist in predicting a flareup of polymyositis
- Estimate damage from skeletal muscle injury or myocardial infarction (MI)

RESULT:

Increased in:

Conditions that cause muscle damage; damaged muscle cells release myoglobin into circulation.

- Cardiac surgery
- Cocaine use (**Rhabdomyolysis is a complication of cocaine use or overdose**)
- Exercise
- Malignant hyperthermia
- MI
- Progressive muscular dystrophy
- Renal failure
- Rhabdomyolysis
- Shock
- Thrombolytic therapy

Decreased in:

- Myasthenia gravis
- Presence of antibodies to myoglobin, as seen in patients with polymyositis
- Rheumatoid arthritis

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of skeletal or myocardial muscle damage.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's cardiovascular and musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address

any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, ANP, blood gases, BNP, calcium, cholesterol (total, HDL, and LDL), CRP, CK and isoenzymes, CT cardiac scoring, echocardiography, echocardiography transesophageal, ECG, exercise stress test, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI chest, MI infarct scan, myoglobin, pericardial fluid analysis, PET heart, potassium, triglycerides, and troponin.
- ▶ Refer to the Cardiovascular and Musculoskeletal System tables at the back of the book for related tests by body system.

Nerve Fiber Analysis

SYNONYM/ACRONYM: NFA.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: There are over 1 million ganglion nerve cells in the retina of each eye. Each nerve cell has a long fiber that travels through the nerve fiber layer of the retina and exits the eye through the optic nerve. The optic nerve is made up of all the ganglion nerve fibers and connects the eye to the brain for vision to occur. As the ganglion cells die, the nerve fiber layer becomes thinner and an empty space in the optic nerve, called the cup, becomes larger. The thinning of the nerve fiber layer and the enlargement of the nerve fiber cup are measurements used to gauge the extent of damage to the retina. Significant damage to the nerve fiber layer occurs before loss of vision is noticed by the patient. Damage can be caused by glaucoma or by aging or occlusion of the vessels in the retina. Ganglion cell loss due to glaucoma begins in the periphery of the retina, thereby first affecting peripheral vision. This change in vision can also be detected by visual field testing. There are several different techniques for measuring nerve fiber layer thickness. One of the most common employs the use of a laser that emits polarizing light waves. The laser's computer measures the change in direction of alignment of the light beam after it passes through the nerve fiber layer tissue. The amount of change in polarization correlates to the thickness of the retinal nerve fiber layer.

INDICATIONS:

- Assist in the diagnosis of eye diseases
- Determine retinal nerve fiber layer thickness
- Monitor the effects of various therapies or the progression of conditions resulting in loss of vision

RESULT:

Normal findings in:

- Normal nerve fiber layer thickness

Abnormal findings in:

- Glaucoma or suspicion of glaucoma
- Ocular hypertension

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- Inability of the patient to fixate on focal point
- Corneal disorder that prevents proper alignment of the retinal nerve fibers
- Dense cataract that prevents visualization of a clear nerve fiber image
- Inability of the patient to cooperate or remain still during the test because of age, significant pain, or mental status

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure measures the thickness of the retinal nerve fiber layer.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of narrow-angle glaucoma. Obtain a history of known or suspected visual impairment, changes in visual acuity, and use of glasses or contact lenses.
- ▶ Obtain a history of the patient's known or suspected vision loss, including type and cause; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.
- ▶ Review the procedure with the patient. Explain that the patient will be requested to fixate the eyes during the procedure. Address concerns about pain and explain that no pain will be experienced during the test, but there may be moments of discomfort. Explain to the patient that some discomfort may be experienced after the test when the numbness wears off from anesthetic drops administered prior to the test. Inform the patient that a health care provider (HCP) performs the test and that to evaluate both eyes, the test can take 10 to 15 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ▶ Seat the patient comfortably. Instruct the patient to look straight ahead, keeping the eyes open and unblinking.

- ▶ Instill topical anesthetic in each eye, as ordered, and allow time for it to work. Topical anesthetic drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semitransparent area of the eyeball where the cornea and sclera meet). Neither the dropper nor the bottle should touch the eyelashes.
- ▶ The equipment used to perform the test determines whether dilation of the pupils is required (OCT) or avoided (GDx).
- ▶ Request that the patient look straight ahead at a fixation light with the chin in the chin rest and forehead against the support bar. The patient should be reminded not to move the eyes or blink the eyelids as the measurement is taken. The person performing the test can store baseline data or retrieve previous images from the equipment. The equipment can create the mean image from current and previous data, and its computer can make a comparison against previous images.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to vision loss or anticipated loss of driving privileges. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide contact information, if desired, for the Glaucoma Research Foundation (www.glaucoma.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient in the use of any ordered medications, usually eye drops. Explain the importance of adhering to the therapy regimen, especially since glaucoma does not present symptoms. Instruct the patient in both the ocular side effects and systemic reactions associated with the prescribed medication. Encourage him or

her to review corresponding literature provided by a pharmacist. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation

to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include fundus photography, gonioscopy, pachymetry, slit-lamp biomicroscopy, and visual field testing.
- ▶ Refer to the Ocular System table at the back of the book for related tests by body system.

Osmolality, Blood and Urine

SYNONYM/ACRONYM: Osmo.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube; urine (5 mL) from an unpreserved random specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Freezing point depression)

	Conventional Units	SI Units (Conventional Units × 1)
Serum	275–295 mOsm/kg	275–295 mmol/kg
Urine		
Newborn	75–300 mOsm/kg	75–300 mmol/kg
Children and Adults	250–900 mOsm/kg	250–900 mmol/kg

DESCRIPTION: Osmolality refers to the number of particles in solution; it is independent of particle size, shape, and charge. Measurement of osmotic concentration in serum provides clinically useful information about water and dissolved-particle transport across fluid compartment membranes. Osmolality is used to assist in the diagnosis of metabolic, renal, and endocrine disorders. The simultaneous determination of serum and urine osmolality provides the opportunity to compare values between the two fluids. A normal urine-to-serum ratio is approximately 0.2 to 4.7 for random samples and greater than 3.0 for first-morning samples (dehydration normally occurs overnight). The major dissolved particles that contribute to osmolality are sodium, chloride, bicarbonate, urea, and glucose. Some of these substances are used in the following calculated estimate:

$$\text{Serum osmolality} = (2 \times \text{Na}^+) + (\text{glucose}/18) + (\text{BUN}/2.8)$$

Measured osmolality is higher than the estimated value. The osmolal gap is the difference between the measured and

calculated values and is normally 5 to 10 mOsm/kg. If the difference is greater than 15 mOsm/kg, consider ethylene glycol, isopropanol, methanol, or ethanol toxicity. These substances behave like antifreeze, lowering the freezing point in the blood, and provide misleadingly high results.

INDICATIONS:

Serum:

- Assist in the evaluation of antidiuretic hormone (ADH) function
- Assist in rapid screening for toxic substances, such as ethylene glycol, ethanol, isopropanol, and methanol
- Evaluate electrolyte and acid-base balance
- Evaluate state of hydration

Urine:

- Evaluate concentrating ability of the kidneys
- Evaluate diabetes insipidus
- Evaluate neonatal patients with protein or glucose in the urine
- Perform work-up for renal disease

RESULT:

Increased in:

- Serum:
Azotemia (*Nitrogen containing waste products that contribute to osmolality accumulate in the blood*)

Dehydration (**Hemoconcentration**)

Diabetes insipidus (**Excessive loss of water through urination results in hemoconcentration**)

Diabetic ketoacidosis (**Excessive loss of water through urination results in hemoconcentration**)

Hypercalcemia (**Electrolyte imbalance that results in water loss and hemoconcentration**)

Hypertatremia (**Related to insufficient intake of water or excessive loss of water; sodium is a major cation in the determination of osmolality**)

- Urine:
 - Amyloidosis
 - Azotemia (**Decrease in renal blood flow; decrease in water excreted by the kidneys results in a more concentrated urine**)
 - Congestive heart failure (**Decrease in renal blood flow related to diminished cardiac output; decrease in water excreted by the kidneys results in a more concentrated urine**)
 - Dehydration (**Decrease in water excreted by the kidneys results in a more concentrated urine**)
 - Hyponatremia
 - Syndrome of inappropriate antidiuretic hormone production (SIADH) (**Related to overproduction of ADH; decrease in water excreted by the kidneys results in a more concentrated urine**)

Decreased in:

- Serum:
 - Adrenocorticoid insufficiency
 - Hyponatremia
 - SIADH
 - Water intoxication
- Urine:
 - Diabetes insipidus
 - Hypertatremia
 - Hypokalemia
 - Primary polydipsia

CRITICAL VALUES:

Serum:

Less than 265 mOsm/kg
Greater than 320 mOsm/kg

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

Serious clinical conditions may be associated with elevated or decreased serum osmolality. The following conditions are associated with elevated serum osmolality:

Respiratory arrest: 360 mOsm/kg
Stupor of hyperglycemia: 385 mOsm/kg
Grand mal seizures: 420 mOsm/kg
Death: greater than 420 mOsm/kg

Symptoms of critically high levels include poor skin turgor, listlessness, acidosis (decreased pH), shock, seizures, coma, and cardiopulmonary arrest. Intervention may include close monitoring of electrolytes, administering intravenous fluids with the appropriate composition to shift water either into or out of the intravascular space as needed, monitoring cardiac signs, continuing neurological checks, and taking seizure precautions.

INTERFERING FACTORS:

- Drugs that may increase serum osmolality include citrates (as an anticoagulant), corticosteroids, ethylene glycol, glycerin, inulin, ioxithalamic acid, mannitol, and methoxyflurane.
- Drugs that may decrease serum osmolality include bendroflumethiazide, carbamazepine, chlorpromazine, chlorthalidone, cyclophosphamide, cyclothiazide, hydrochlorothiazide, lorcaïnide, methyclothiazide, and polythiazide.
- Drugs that may increase urine osmolality include anesthetic agents, chlorpropamide, cyclophosphamide, furosemide, mannitol, metolazone, octreotide, phloridzin, and vincristine.
- Drugs that may decrease urine osmolality include captopril, demeclocycline, glyburide, lithium, methoxyflurane, octreotide, tolazamide, and verapamil.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate electrolyte and water balance.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that blood specimen collection takes approximately 5 to 10 min; random urine collection takes approximately 5 min and depends on the cooperation of the patient. Urine specimen collection may also be timed. Address concerns about pain and explain that there may be some discomfort during the venipuncture; there will be no discomfort during urine collection.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Direct the patient to breathe normally and to avoid unnecessary movement during the venipuncture.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes or collection containers with the corresponding patient demographics, date, and time of collection.

Blood:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for

bleeding or hematoma formation and secure gauze with adhesive bandage.

Urine:

- ▶ Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device.
- ▶ Either a random specimen or a timed collection may be requested. For timed specimens, a 12- or 24-hr time frame for urine collection may be ordered. Inform the patient that all urine must be saved during that 12- or 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Blood or Urine:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.

- ▶ **Nutritional considerations:** Decreased osmolality may be associated with overhydration. Observe the patient for signs and symptoms of fluid-volume excess related to excess electrolyte intake, fluid-volume deficit related to active body fluid loss, or risk of injury related to an alteration in body chemistry. (For electrolyte-specific dietary references, see monographs titled “Chloride,” “Potassium,” and “Sodium.”)
- ▶ Increased osmolality may be associated with dehydration. Evaluate the patient for signs and symptoms of dehydration. Dehydration is a significant and common finding in geriatric and other patients in whom renal function has deteriorated.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the National Kidney Foundation (www.kidney.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, anion gap, ammonia, ADH, ANP, BNP, BUN, calcium, carbon dioxide, chloride, cortisol, creatinine, echocardiography, echocardiography transesophageal, ethanol, glucose, complete blood count, hematocrit, complete blood count, hemoglobin, ketones, lung perfusion scan, magnesium, phosphorus, potassium, sodium, and UA.
- ▶ Refer to the Endocrine and Genitourinary System tables at the back of the book for related tests by body system.

Osmotic Fragility

SYNONYM/ACRONYM: Red blood cell osmotic fragility, OF.

SPECIMEN: Whole blood (1 mL) collected in a green-top (heparin) tube and two peripheral blood smears.

REFERENCE VALUE: (Method: Spectrophotometry) Hemolysis (unincubated) begins at 0.5 w/v sodium chloride (NaCl) solution and is complete at 0.3 w/v NaCl solution. Results are compared to a normal curve.

RESULT:

Increased in:
Conditions that produce red blood cells (RBCs) with a small surface to volume ratio or RBCs that are rounder than normal will have increased osmotic fragility.

- Acquired immune hemolytic anemias (**Abnormal RBCs in size and shape; spherocytes**)

- Hemolytic disease of the newborn (**Abnormal RBCs in size and shape; spherocytes**)
- Hereditary spherocytosis (**Abnormal RBCs in size and shape; spherocytes**)
- Malaria (**Related to affect of parasite on RBC membrane integrity**)
- Pyruvate kinase deficiency (**Abnormal RBCs in size and shape; spherocytes**)

Decreased in:

Conditions that produce RBCs with a large surface to volume ratio or RBCs that are flatter than normal will have decreased osmotic fragility.

- Asplenia (*Abnormal cells are not removed from circulation due to absence of spleen; target cells*)
- Hemoglobinopathies (*Abnormal RBCs in size and shape; target cells, drepanocytes*)

- Iron-deficiency anemia (*Abnormal RBCs in size and shape; target cells*)
- Liver disease (*Abnormal RBCs in size and shape; target cells*)
- Thalassemias (*Abnormal RBCs in size and shape; target cells*)

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Osteocalcin

SYNONYM/ACRONYM: Bone GLA protein, BGP.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

Age and Sex	Conventional Units	SI Units (Conventional Units × 1)
Newborn	20–40 ng/mL	20–40 mcg/L
1–17 y	2.8–41 ng/mL	2.8–41 mcg/L
Adult		
Male	3–13 ng/mL	3–13 mcg/L
Female		
Premenopausal	0.4–8.2 ng/mL	0.4–8.2 mcg/L
Postmenopausal	1.5–11 ng/mL	1.5–11 mcg/L

DESCRIPTION: Osteocalcin is an important bone cell matrix protein and a sensitive marker in bone metabolism. It is produced by osteoblasts during the matrix mineralization phase of bone formation and is the most abundant noncollagenous bone cell protein. Synthesis of osteocalcin is dependent on vitamin K. Osteocalcin levels parallel alkaline phosphatase levels. Osteocalcin levels are

affected by a number of factors, including the hormone estrogen. Assessment of osteocalcin levels permits indirect measurement of osteoblast activity and bone formation. Because it is released into the bloodstream during bone resorption, there is some question as to whether osteocalcin might also be considered a marker for bone matrix degradation and turnover.

INDICATIONS:

- Assist in the diagnosis of bone cancer
- Evaluate bone disease
- Evaluate bone metabolism
- Monitor effectiveness of estrogen replacement therapy

RESULT:**Increased in:**

- Adolescents undergoing a growth spurt (**Levels in the blood increase as the rate of bone formation increases**)
- Chronic renal failure (**Related to accumulation in circulation due to decreased renal excretion**)
- Hyperthyroidism (primary and secondary) (**Related to increased bone turnover**)
- Metastatic skeletal disease (**Levels in the blood increase as bone destruction releases it into circulation**)
- Paget's disease (**Levels in the blood increase as bone destruction releases it into circulation**)
- Renal osteodystrophy (**Related to bone degeneration secondary to hyperparathyroidism of chronic renal failure**)
- Some patients with osteoporosis (**Levels in the blood increase as bone destruction releases it into circulation**)

Decreased in:

- Growth hormone deficiency (**Bone mineralization is stimulated by growth hormone**)
- Pregnancy (**Increased demand by developing fetus results in an increase in maternal bone resorption**)
- Primary biliary cirrhosis (**Related to increased bone loss**)

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase osteocalcin levels include anticonvulsants, calcitriol, and estrogens.

- Drugs that may decrease osteocalcin levels include glucocorticoids.
- Recent radioactive scans or radiation within 1 week before the serum osteocalcin test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate bone disease.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ♦ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient

demographics, date, and time of collection. Perform a venipuncture.

- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Nutritional considerations:** Increased osteocalcin levels may be associated with skeletal disease. Nutritional therapy is indicated for individuals identified as being at high risk for developing osteoporosis. Educate the patient regarding the National Osteoporosis Foundation's guidelines, which include a regular regimen of weight-bearing exercises, limited alcohol intake, avoidance of tobacco products, and adequate dietary intake of vitamin D (400 to 800 IU/day) and calcium (120 mg/day). Dietary calcium can be obtained from animal or plant sources. Milk and milk products, sardines, clams, oysters, salmon, rhubarb, spinach, beet greens, broccoli, kale, tofu, legumes, and fortified orange juice are high in calcium. Milk and milk products also contain vitamin D and lactose, which assist calcium absorption. Cooked vegetables yield more

absorbable calcium than raw vegetables. Patients should be informed of the substances that can inhibit calcium absorption by irreversibly binding to some of the calcium, making it unavailable for absorption, such as oxalates, which naturally occur in some vegetables; phytic acid, found in some cereals; and insoluble dietary fiber (in excessive amounts). Excessive protein intake can also negatively affect calcium absorption, especially if it is combined with foods high in phosphorus. Vitamin D is synthesized by the skin and is also available in fortified dairy foods and cod liver oil.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ALP, biopsy bone, BMD, bone scan, calcium, collagen cross-linked N-telopeptide, MRI musculoskeletal, PTH, phosphorus, radiography bone, and vitamin D.
- Refer to the Musculoskeletal System table for related tests by body system.

Otoscopy

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Ears.

CONTRAST: N/A.

DESCRIPTION: This noninvasive procedure is used to inspect the external ear, auditory canal, and tympanic membrane. Otoscopy is an essential part of any general

physical examination, but is also done before any other audiological studies when symptoms of ear pain or hearing loss are present.

INDICATIONS:

- Detect causes of deafness, obstruction, stenosis, or swelling of the pinna or canal causing a narrowing or closure that prevents sound from entering
- Detect ear abnormalities during routine physical examination
- Diagnose cause of ear pain
- Remove impacted cerumen (with a dull ring curette) or foreign bodies (with a forceps) that are obstructing the entrance of sound waves into the ear
- Evaluate acute or chronic otitis media and effectiveness of therapy in controlling infections

RESULT:**Normal findings in:**

- Normal structure and appearance of the external ear, auditory canal, and tympanic membrane.

Pinna: funnel-shaped cartilaginous structure; no evidence of infection, pain, dermatitis with swelling, redness, or itching

External auditory canal: S-shaped canal lined with fine hairs, sebaceous and ceruminous glands; no evidence of redness, lesions, edema, scaliness, pain, accumulation of cerumen, drainage, or presence of foreign bodies

Tympanic membrane: shallow, circular cone that is shiny and pearl gray in color, semitransparent whitish cord crossing from front to back just under the upper edge, cone of light on the right side at the 4 o'clock position; no evidence of bulging, retraction, lusterless membrane, or obliteration of the cone of light

Abnormal findings in:

- Cerumen accumulation
- Ear trauma
- Foreign bodies
- Otitis externa
- Otitis media
- Tympanic membrane perforation or rupture

CRITICAL VALUES: N/A**INTERFERING FACTORS:****Factors that may impair the results of the examination:**

- Obstruction of the auditory canal with cerumen, dried drainage, or foreign bodies that prevent introduction of the otoscope

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure is performed to investigate suspected ear disorders.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's known or suspected hearing loss, including type and cause; ear conditions with treatment regimens; ear surgery; and other tests and procedures to assess and diagnose auditory deficit. Obtain a history of the patient's complaints of pain, itching, drainage, deafness, or presence of tympanotomy tube.
- ♦ Obtain a history of symptoms and results of previously performed laboratory tests, diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, especially antibiotic regimens, as well as herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the caregiver that he or she may need to restrain a child in order to prevent damage to the ear if the child cannot remain still. Address concerns about pain and explain that no discomfort will be experienced during the test. Inform the patient that a health care provider (HCP) performs the test, and that to evaluate both ears, the test can take 5 to 10 min.
- ♦ **Sensitivity to social and cultural issues,** as well as Concern for modesty, is important

in providing psychological support before, during, and after the procedure.

- There are no food, fluid, or medication restrictions, unless by medical direction.
- Ensure that the external auditory canal is clear of impacted cerumen.

INTRATEST:

- Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- Administer ear drops or irrigation to prepare for cerumen removal, if ordered.
- Place adult patient in a sitting position; place a child in a supine position on the caregiver's lap. Request that the patient remain very still during the examination; a child can be restrained by the caregiver if needed.
- Assemble the otoscope with the correct-size speculum to fit the size of the patient's ear and check the light source. For the adult, tilt the head slightly away and, with the nondominant hand, pull the pinna upward and backward. For a child, hold the head steady or have the caregiver hold the child's head steady, depending on the age, and pull the pinna downward. Gently and slowly insert the speculum into the ear canal downward and forward with the handle of the otoscope held downward. For the child, hold the handle upward while placing the edge of the hand holding the otoscope on the head to steady it during insertion. If the speculum resists insertion, withdraw and attach a smaller one.
- Place an eye to the lens of the otoscope, turn on the light source, and advance the speculum into the ear canal until the tympanic membrane is visible. Examine the posterior and anterior membrane, cone of light, outer rim (annulus), umbo, handle of the malleus, folds, and pars tensa.
- Culture any effusion with a sterile swab and culture tube (see "Culture,

Bacterial, Ear," monograph); or a HCP will perform needle aspiration from the middle ear through the tympanic membrane during the examination. Other procedures such as cerumen and foreign body removal can also be performed.

- Pneumatic otoscopy can be done to determine tympanic membrane flexibility. This test permits the introduction of air into the canal that reveals a reduction in movement of the membrane in otitis media and absence of movement in chronic otitis media.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Administer ear drops of a soothing oil, as ordered, if the canal is irritated by removal of cerumen or foreign bodies.
- Recognize anxiety related to test results, and be supportive of impaired activity related to hearing loss. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include audiometry hearing loss, culture bacterial (ear), and gram stain.
- Refer to the Auditory System table at the back of the book for related tests by body system.

Ova and Parasites, Stool

SYNONYM/ACRONYM: O & P.

SPECIMEN: Stool collected in a clean plastic, tightly capped container.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination) No presence of parasites, ova, or larvae.

DESCRIPTION: This test evaluates stool for the presence of intestinal parasites and their eggs. Some parasites are nonpathogenic; others, such as protozoa and worms, can cause serious illness.

Taenia saginata, *T. solium* infection

- Trematode disease—*Clonorchis sinensis*, *Fasciola hepatica*, *Fasciolopsis buski* infection
- Trichuriasis—*Trichuris trichiura* infection

CRITICAL VALUES: N/A

INDICATIONS:

Assist in the diagnosis of parasitic infestation.

RESULT:

Positive findings in:

- Amebiasis—*Entamoeba histolytica* infection
- Ascariasis—*Ascaris lumbricoides* infection
- Blastocystis—*Blastocystis hominis* infection
- Cryptosporidiosis—*Cryptosporidium parvum* infection
- Enterobiasis—*Enterobius vermicularis* (pinworm) infection
- Giardiasis—*Giardia lamblia* infection
- Hookworm disease—*Ancylostoma duodenale*, *Necator americanus* infection
- Isospora—*Isospora belli* infection
- Schistosomiasis—*Schistosoma haematobium*, *S. japonicum*, *S. mansoni* infection
- Strongyloidiasis—*Strongyloides stercoralis* infection
- Tapeworm disease—
Diphyllobothrium, *Hymenolepiasis*,

INTERFERING FACTORS:

- Failure to test a fresh specimen may yield a false-negative result.
- Antimicrobial or antiamebic therapy within 10 days of test may yield a false-negative result.
- Failure to wait 1 wk after a gastrointestinal study using barium or after laxative use can affect test results.
- Medications such as antacids, antibiotics, antidiarrheal compounds, bismuth, castor oil, iron, magnesium, or psyllium fiber (Metamucil) may interfere with analysis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of parasitic infection.
- ▶ Obtain a history of the patient's complaints, including a list of known

allergens. Document any travel to foreign countries.

- ▶ Obtain a history of the patient's gastrointestinal and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent therapies that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Instruct the patient on handwashing procedures, and inform the patient that the infection may be contagious. Warn the patient not to contaminate the specimen with urine, toilet paper, or toilet water. Address concerns about pain and explain to the patient that there should be no discomfort during the procedure.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to avoid medications that interfere with test results.
- ▶ There are no food or fluid restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.
- ▶ Collect a stool specimen directly into the container. If the patient is bedridden, use a clean bedpan and transfer the specimen into the container using a tongue depressor.
- ▶ Specimens to be examined for the presence of pinworms are collected by the "Scotch tape" method in the

morning before bathing or defecation.

A small paddle with a piece of cellophane tape (sticky side facing out) is pressed against the perianal area. The tape is placed in a collection container and submitted to determine if ova are present. Sometimes adult worms are observed protruding from the rectum.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Educate the patient with positive findings on the transmission of the parasite, as indicated. Warn the patient that one negative result does not rule out parasitic infestation and that additional specimens may be required. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy intestinal, biopsy liver, biopsy muscle, culture stool, fecal analysis, and IgE.
- ▶ Refer to the Gastrointestinal and Immune System tables at the back of the book for related tests by body system.

Oxalate, Urine

SYNONYM/ACRONYM: N/A.

SPECIMEN: Urine (25 mL) from a timed specimen collected in a clean plastic collection container with hydrogen chloride (HCl) as a preservative.

REFERENCE VALUE: (Method: Spectrophotometry)

Conventional Units

0–40 mg/24 hr

SI Units (Conventional Units × 11.4)

0–456 micromol/24 hr

DESCRIPTION: Oxalate is derived from the metabolism of oxalic acid, glycine, and ascorbic acid. Some individuals with malabsorption disorders absorb and excrete abnormally high amounts of oxalate, resulting in *hyperoxaluria*. Hyperoxaluria may be seen in patients who consume large amounts of animal protein, certain fruits and vegetables, or megadoses of vitamin C (ascorbic acid). Hyperoxaluria is also associated with ethylene glycol poisoning (oxalic acid is used in cleaning and bleaching agents). Patients who absorb and excrete large amounts of oxalate may form calcium oxalate kidney stones. Simultaneous measurement of serum and urine calcium is often requested.

INDICATIONS:

- Assist in the evaluation of patients with ethylene glycol poisoning
- Assist in the evaluation of patients with a history of kidney stones
- Assist in the evaluation of patients with malabsorption syndromes or patients who have had jejunioileal bypass surgery

RESULT:

Increased in:

Conditions that result in malabsorption for any reason can lead to increased levels. Chronic diarrhea results in excessive loss of calcium to bind oxalate. Increased oxalate is absorbed by the intestine and excreted by the kidneys.

- Bacterial overgrowth
- Biliary tract disease
- Bowel disease
- Celiac disease
- Cirrhosis
- Crohn's disease
- Diabetes
- Ethylene glycol poisoning
(Ethylene glycol is metabolized to oxalate and excreted by the kidneys; crystals are present in urine)
- Ileal resection
- Jejunal shunt
- Pancreatic disease
- Primary hereditary hyperoxaluria (rare)
- Pyridoxine (vitamin B₆) deficiency
(Pyridoxine is a cofactor in an enzyme reaction that converts glyoxylic acid to glycine; deficiencies results in an increase in oxalate)
- Sarcoidosis

Decreased in:

- Hypercalciuria (*Related to formation of calcium oxalate crystals*)
- Renal failure (*Related to oxalate kidney stone disease*)

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs and vitamins that may increase oxalate levels include methoxyflurane, ascorbic acid, and calcium.
- Drugs that may decrease oxalate levels include nifedipine and pyridoxine.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify patients at risk for renal calculus formation, specifically calcium oxalate calculi. Hyperoxaluria is also commonly observed in patients with malabsorption conditions.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal (GI) and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ There are no fluid or medication restrictions, unless by medical direction.
- ▶ Calcium supplements, gelatin, rhubarb, spinach, strawberries, tomatoes, and vitamin C should be restricted for at least 24 hr before the test. High-protein meals should also be avoided 24 hr before specimen collection. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that restricted foods have been avoided for at least 24 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):**Clean-Catch Specimen:**

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.

- ◆ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ◆ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

- ◆ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ◆ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ◆ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ◆ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- ◆ Include on the collection container's label the amount of urine, test start

and stop times, and ingestion of any foods or medications that can affect test results.

General:

- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual diet, as directed by the HCP.
- ◆ **Nutritional considerations:** Consideration may be given to lessening dietary intake of oxalate if urine levels are increased. Encourage patients with abnormal results to seek advice regarding dietary modifications from a trained nutritionist. Magnesium supplementation may be recommended for patients with GI disease to prevent the development of calcium oxalate kidney stones.
- ◆ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include calcium, calculus kidney stone panel, UA, urine uric acid, and vitamin C.
- ◆ Refer to the Gastrointestinal and Genitourinary System tables at the back of the book for related tests by body system.

Pachymetry

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: Pachymetry is the measurement of the thickness of the cornea using an ultrasound device called a pachymeter. Refractive surgery procedures such as LASIK remove tissue from the cornea. Pachymetry is used to ensure that there will be enough central corneal tissue remaining after surgery to prevent ectasia, or abnormal bowing, of thin corneas. Also, studies point to a correlation between increased risk of glaucoma and decreased corneal thickness. This correlation has influenced some health care providers (HCPs) to include pachymetry as a part of a regular eye health examination for patients who have a family history of glaucoma or who are part of a high-risk population. African Americans have a higher incidence of glaucoma than any other ethnic group.

INDICATIONS:

- Assist in the diagnosis of glaucoma (*note:* the intraocular pressure in glaucoma patients with a thin cornea, 530 or less, may be higher than in patients whose corneal thickness is within normal limits)
- Determine corneal thickness in potential refractive surgery candidates
- Monitor the effects of various therapies using eye drops, laser, or filtering surgery

RESULT:

Normal findings in:

- 535 to 555 micron

Abnormal findings in:

- Bullous keratopathy
- Corneal rejection after penetrating keratoplasty
- Fuchs endothelial dystrophy
- Glaucoma

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the test because of age, significant pain, or mental status
- Improper technique during application of the probe tip to the cornea

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure measures corneal thickness.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of narrow-angle glaucoma. Obtain a history of known or suspected visual impairment, changes in visual acuity, and use of glasses or contact lenses.

P

- ▶ Obtain a history of the patient's known or suspected vision loss, including type and cause; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests, diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.
- ▶ Review the procedure with the patient. Explain that the patient will be requested to fixate the eyes during the procedure. Address concerns about pain and explain that no pain will be experienced during the test, but there may be moments of discomfort. Explain to the patient that some discomfort may be experienced after the test when the numbness wears off from anesthetic drops administered prior to the test, or discomfort may occur if too much pressure is used during the test. Inform the patient that a HCP performs the test, and that to evaluate both eyes, the test can take 3 to 5 min.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ▶ Seat the patient comfortably. Instruct the patient to look straight ahead, keeping the eyes open and unblinking.
- ▶ Instill topical anesthetic in each eye, as ordered, and allow time for it to work. Topical anesthetic drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye)

near the limbus (grey, semitransparent area of the eyeball where the cornea and sclera meet). Neither the dropper nor the bottle should touch the eyelashes.

- ▶ Request that the patient look straight ahead while the probe of the pachymeter is applied directly on the cornea of the eye. Take an average of three readings for each eye. Individual readings should be within 10 microns. Results on both eyes should be similar.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
 - ▶ Recognize anxiety related to test results. Encourage the family to recognize and be supportive of impaired activity related to vision loss, anticipated loss of driving privileges, or the possibility of requiring corrective lenses (self-image). Discuss the implications of test results on the patient's lifestyle. Reassure the patient regarding concerns related to their impending cataract surgery. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide contact information, if desired, for the Glaucoma Research Foundation (www.glaucoma.org).
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.
- #### RELATED MONOGRAPHS:
- ▶ Related tests include fundus photography, gonioscopy, intraocular pressure, and visual field testing.
 - ▶ Refer to the Ocular System table at the back of the book for related tests by body system.

Papanicolaou Smear

SYNONYM/ACRONYM: Pap smear, cervical smear.

SPECIMEN: Cervical and endocervical cells.

REFERENCE VALUE: (Method: Microscopic examination of fixed and stained smear) Reporting of Pap smear findings may follow one of several formats and may vary from laboratory to laboratory. Simplified content of the two most common formats for interpretation are listed in the table.

Bethesda System	Description
Specimen type	Conventional, liquid-based, or other
Specimen adequacy	<p>Satisfactory for evaluation—endocervical/transformation zone component is described as present/absent along with other quality indicators, e.g., partially obscuring blood, inflammation</p> <p>Unsatisfactory for evaluation—either the specimen is rejected and the reason given or the specimen is processed and examined but not evaluated for epithelial abnormalities and the reason is given</p>
General categorization	<p>Negative for intraepithelial lesion or malignancy</p> <p>Epithelial cell abnormality (abnormality is specified in the interpretation section of the report)</p> <p>Other comments</p>
Automated review	Indicates the case was examined by an automated device and the results are listed along with the name of the device
Ancillary testing	Describes the test method and result
Interpretation/result	<p>Organisms—<i>Trichomonas vaginalis</i>, fungal organisms consistent with <i>Candida</i> spp., shift in flora suggestive of bacterial vaginosis, bacteria morphologically consistent with <i>Actinomyces</i> spp., cellular changes consistent with Herpes simplex virus</p> <p>Other nonneoplastic findings—reactive cellular changes associated with inflammation, radiation, intrauterine device; glandular cell status post-hysterectomy; atrophy; endometrial cells (in a woman of 40 yr or greater)</p>
Epithelial cell abnormalities	
Squamous cell	<p>Atypical squamous cells</p> <ul style="list-style-type: none"> • of undetermined significance (ASC-US) • cannot exclude HSIL (ASC-H) <p>Low grade squamous intraepithelial lesion (LSIL)</p> <ul style="list-style-type: none"> • encompassing: HPV/mild dysplasia/CIN 1 <p>High grade squamous intraepithelial lesion (HSIL)</p> <ul style="list-style-type: none"> • encompassing: moderate and severe dysplasia

(table continues on page 916)

Bethesda System	Description
Glandular cell	CIS/CIN 2 and CIN 3 <ul style="list-style-type: none"> with features suspicious for invasion (if invasion is suspected)
	Squamous cell carcinoma
	Atypical <ul style="list-style-type: none"> endocervical cells (NOS or specify otherwise) endometrial cells (NOS or specify otherwise) glandular cells (NOS or specify otherwise)
	Atypical <ul style="list-style-type: none"> endocervical cells, favor neoplastic glandular cells, favor neoplastic
	Endocervical carcinoma in situ
Other malignant neoplasms	Adenocarcinoma <ul style="list-style-type: none"> endocervical endometrial extrauterine not otherwise specified (NOS) Specify:
Educational notes and suggestions	Should be consistent with clinical follow-up guidelines published by professional organizations with references included

DESCRIPTION: The Papanicolaou (Pap) smear is primarily used for the early detection of cervical cancer. The interpretation of Pap smears is as heavily dependent on the collection and fixation technique as it is on the completeness and accuracy of the clinical information provided with the specimen. The patient's age, date of last menstrual period, parity, surgical status, postmenopausal status, use of hormone therapy (including use of oral contraceptives), history of radiation or chemotherapy, history of abnormal vaginal bleeding, and history of previous Pap smears are essential for proper interpretation. Human papillomavirus (HPV) is the most common sexually transmitted virus and primary causal factor in the development of cervical

cancer. It is for this reason that specimens for HPV are often collected simultaneously with the PAP smear. The laboratory should be consulted about the availability of this option prior to specimen collection as specific test kits are required to allow for simultaneous sample collection. HPV infection can be successfully treated once it has been identified. Gardasil®, the first vaccine developed against HPV, is given at 2 and 6 mo respectively, after the initial injection. CDC recommends vaccination for females age 11 and 12 yr. Vaccination is also recommended for females age 13 to 26 yr who haven't been previously vaccinated.

A wet prep can be prepared simultaneously from a cervical or vaginal sample. The swab is

touched to a microscope slide and a small amount of saline is dropped on the slide. The slide is examined by microscope to determine the presence of harmful bacteria or trichomonas.

A Schiller's test entails applying an iodine solution to the cervix. Normal cells pick up the iodine and stain brown. Abnormal cells do not pick up any color.

Improvements in specimen preparation have added to the increased quality of screening procedures. The Cytoc ThinPrep PapTest (www.cytoc.com/), approved by the U.S. Food and Drug Administration in 1996, is a technique that provides a uniform monolayer of cells free of debris such as blood and mucus. Computerized scanning systems are also being used to reduce the number of smears that require manual review by a cytotechnologist or pathologist.

There are now some alternatives to cone biopsy and cryosurgery for the treatment of cervical dysplasia. Patients with abnormal Pap smear results may have a cervical loop electrosurgical excision procedure (LEEP) performed to remove or destroy abnormal cervical tissue. In the LEEP procedure, a speculum is inserted into the vagina, the cervix is numbed, and a special electrically charged wire loop is used to painlessly remove the suspicious area. Postprocedure cramping and bleeding can occur. Laser ablation is another technique that can be employed for the precise removal of abnormal cervical tissue.

INDICATIONS:

- Assist in the diagnosis of cervical dysplasia
- Assist in the diagnosis of endometriosis, condyloma, and vaginal adenosis
- Assist in the diagnosis of genital infections (herpes, *Candida* spp., *Trichomonas vaginalis*, cytomegalovirus, *Chlamydia*, lymphogranuloma venereum, HPV, and *Actinomyces* spp.)
- Assist in the diagnosis of primary and metastatic neoplasms
- Evaluate hormonal function

RESULT:

Positive findings in:

(See table [Bethesda system])

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- The smear should not be allowed to air dry before fixation.
- Lubricating jelly should not be used on the speculum.
- Improper collection site may result in specimen rejection. Samples for cancer screening are obtained from the posterior vaginal fornix and from the cervix. Samples for hormonal evaluation are obtained from the vagina.
- Douching, sexual intercourse, using tampons, or using vaginal medication within 24 hr prior to specimen collection can interfere with the specimen's results.
- Collection of other specimens prior to the collection of the Pap smear may be cause for specimen rejection.
- Contamination with blood from samples collected during the patient's menstrual period may be cause for specimen rejection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to establish a histological diagnosis of cervical and vaginal disease and identify the presence of genital infections.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Instruct the patient to avoid douching or sexual intercourse for 24 hr before specimen collection. Verify that the patient is not menstruating. Address concerns about pain and explain that there may be some discomfort during the procedure. Inform the patient that specimen collection is performed by a health care provider (HCP) specializing in this procedure and takes approximately 5 to 10 min.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ If the patient is taking vaginal antibiotic medication, testing should be delayed for 1 mo after the treatment has been completed.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Have the patient void before the procedure.
- ▶ Have the patient remove clothes below the waist.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to breathe normally and to avoid unnecessary movement during the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Assist the patient into a lithotomy position on a gynecological examination table (with feet in stirrups). Drape the patient's legs.
- ▶ A plastic or metal speculum is inserted into the vagina and is opened to gently spread apart the vagina for inspection of the cervix. The speculum may be dipped in warm water to aid in comfortable insertion.
- ▶ After the speculum is properly positioned, the cervical and vaginal specimens are obtained. A synthetic fiber brush is inserted deep enough into the cervix to reach the endocervical canal. The brush is then rotated one turn and removed. A plastic or wooden spatula is used to lightly scrape the cervix and vaginal wall.

Conventional Collection:

- ▶ Both specimens that are on the brush and spatula are then plated on the glass slide. The brush specimen is plated using a gentle rolling motion, whereas the spatula specimen is plated using a light gliding motion across the slide. The specimens are immediately fixed to the slide with a liquid or spray containing 95% ethanol. The speculum is removed from the vagina. A pelvic and/or rectal exam is usually performed after specimen collection is completed.

ThinPrep Collection:

- ▶ The ThinPrep bottle lid is opened and removed, exposing the solution. The brush and spatula specimens are then gently swished in the ThinPrep solution

to remove the adhering cells. The brush and spatula are then removed from the ThinPrep solution, and the bottle lid is replaced and secured.

General:

- ◆ Place samples in properly labeled specimen container and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Cleanse or allow the patient to cleanse secretions or excess lubricant (if a pelvic and/or rectal examination is also performed) from the perineal area. Provide a sanitary pad if cervical bleeding occurs.
- ◆ Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient, as appropriate, that repeat testing may be requested in the event of specimen rejection or abnormal findings. Inform the patient that non-sexually active women should begin yearly Pap smears at 18 yr of

age, and younger sexually active women should begin yearly Pap smears earlier. Pap smears should be repeated more frequently if the results return abnormal. After a hysterectomy, a vaginal cuff Pap smear is used to monitor the cells lining the terminal end of the vagina. Several guidelines differ in their recommendations on when to cease Pap smear testing. Encourage older patients to discuss their Pap smear result history and women's health history with their HCP to determine at what age testing may be terminated. Answer any questions or address any concerns voiced by the patient or family.

- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include biopsy cervical, cancer antigens, Chlamydia group antibody, colposcopy, culture anal/genital, culture throat, culture urine, culture viral, CMV, cytology urine, laparoscopy gynecologic, US pelvis, and UA.
- ◆ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Parathyroid Hormone: Intact, C-Terminal, and N-Terminal

SYNONYM/ACRONYM: Parathormone, PTH.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Specimen should be transported tightly capped and in an ice slurry.

REFERENCE VALUE: (Method: Immunoassay)

	Conventional Units	SI Units (Conventional Units × 1)
C-terminal		
1–16 yr	51–217 pg/mL	51–217 ng/L
Adults	50–330 pg/mL	50–330 ng/L
N-terminal		
2–13 yr	14–21 pg/mL	14–21 ng/L
Adult	8–24 pg/mL	8–24 ng/L
Intact		
Cord blood	Less than 3 pg/mL	Less than 3 ng/L
2–20 yr	9–52 pg/mL	9–52 ng/L
Adult	10–65 pg/mL	10–65 ng/L

DESCRIPTION: Parathyroid hormone (PTH) is secreted by the parathyroid glands in response to decreased levels of circulating calcium. PTH assists in the mobilization of calcium from bone into the bloodstream, promoting renal tubular reabsorption of calcium and depression of phosphate reabsorption, thereby reducing calcium excretion and increasing phosphate excretion by the kidneys. PTH also decreases the renal secretion of hydrogen ions, which leads to increased renal excretion of bicarbonate and chloride. PTH enhances renal production of active vitamin D metabolites, causing increased calcium absorption in the small intestine. The net result of PTH action is maintenance of adequate serum calcium levels. In normal individuals, intact PTH has a circulating half-life of about 5 min. N-terminal PTH has a circulating half-life of about 2 min and is found in very small quantities. Intact and N-terminal PTH are the only biologically active forms of the hormone. Ninety percent of circulating PTH is composed of inactive C-terminal and midregion fragments. PTH is cleared from the body by the kidneys.

INDICATIONS:

- Assist in the diagnosis of hyperparathyroidism
- Assist in the diagnosis of suspected secondary hyperparathyroidism due to chronic renal failure, malignant tumors that produce ectopic PTH, and malabsorption syndromes
- Detect incidental damage or inadvertent removal of the parathyroid glands during thyroid or neck surgery
- Differentiate parathyroid and non-parathyroid causes of hypercalcemia
- Evaluate autoimmune destruction of the parathyroid glands
- Evaluate parathyroid response to altered serum calcium levels, especially those that result from malignant processes, leading to decreased PTH production
- Evaluate source of altered calcium metabolism

RESULT:

Increased in:

- Fluorosis (***Skeletal fluorosis can cause a condition resembling secondary hyperparathyroidism, disruption in calcium homeostasis, and excessive PTH production***)
- Primary, secondary, or tertiary hyperparathyroidism (***All result in excess PTH production***)

- Pseudogout (*Calcium is lost due to deposits in the joint; decrease in calcium stimulates PTH production*)
- Pseudohypoparathyroidism
- Zollinger-Ellison syndrome (*Poor intestinal absorption of calcium and vitamin D; decreased calcium stimulates PTH production*)

Decreased in:

- Autoimmune destruction of the parathyroids (*Related to decreased parathyroid function*)
- DiGeorge syndrome (*Related to hypoparathyroidism*)
- Hyperthyroidism (*Related to increased calcium from bone loss; increased calcium levels inhibit PTH production*)
- Hypomagnesemia (*Magnesium is a calcium channel blocker; low magnesium levels allow for increased calcium which inhibits PTH production*)
- Nonparathyroid hypercalcemia (*in the absence of renal failure*) (Increased calcium levels inhibit PTH production)
- Sarcoidosis (*Related to increased calcium levels*)
- Secondary hypoparathyroidism due to surgery

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase PTH levels include clodronate, dopamine, estrogen/progestin therapy, fosfarnet, furosemide, hydrocortisone, isoniazid, lithium, octreotide, pamidronate, phosphates, prednisone, tamoxifen, and verapamil.
- Drugs and vitamins that may decrease PTH levels include alfacalcidol, aluminum hydroxide, calcitriol, cimetidine (C-terminal only), diltiazem, magnesium

sulfate, pindolol, prednisone (intact), and vitamin D.

- PTH levels are subject to diurnal variation, with highest levels occurring in the morning.
- PTH levels should always be measured in conjunction with calcium for proper interpretation.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of parathyroid disease and disorders of calcium balance. It is also used to monitor patients undergoing renal dialysis.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Early-morning specimen collection is recommended because of the diurnal variation in PTH levels. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological

support before, during, and after the procedure.

- ▶ The patient should fast for 12 hr before specimen collection. Protocols may vary from facility to facility.
- ▶ There are no fluid or medication restrictions, unless by medical direction.
- ▶ Prepare an ice slurry in a cup or plastic bag to have on hand for immediate transport of the specimen to the laboratory.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ **Nutritional considerations:** Patients with abnormal parathyroid levels are also likely to experience the effects of calcium level imbalances. Instruct the patient to report signs and symptoms of hypocalcemia and hypercalcemia to the HCP. (For critical values, signs, and symptoms of calcium imbalance, and nutritional information, see monographs titled “Calcium, Blood,” “Calcium, Ionized,” and “Calcium, Urine.”)
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ALP, arthroscopy, calcitonin, calcium, collagen cross-linked telopeptides, evoked brain potentials, fecal fat, gastric emptying scan, gastric acid stimulation, gastrin stimulation test, parathyroid scan, phosphorus, RAIU, synovial fluid analysis, TSH, thyroxine, US thyroid and parathyroid, uric acid, UA, and vitamin D.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Parathyroid Scan

SYNONYM/ACRONYM: Parathyroid scintiscan.

AREA OF APPLICATION: Parathyroid.

CONTRAST: IV technetium-99m (Tc-99m) pertechnetate, Tc-99m sestamibi, oral iodine-123, and thallium.

DESCRIPTION: Parathyroid scanning is performed to assist in the preoperative localization of parathyroid adenomas in clinically proven primary hyperparathyroidism; it is useful for distinguishing between intrinsic and extrinsic parathyroid adenomas. It is also performed after surgery to verify the presence of the parathyroid gland in children, and it is done after thyroidectomy as well.

The radionuclide is administered 10 to 20 min before the imaging is performed. The thyroid and surrounding tissues should be carefully palpated.

Fine-needle aspiration biopsy guided by ultrasound is occasionally necessary to differentiate thyroid pathology, as well as pathology of other tissues, from parathyroid neoplasia.

INDICATIONS:

- Aid in the diagnosis of hyperparathyroidism
- Differentiate between extrinsic and intrinsic parathyroid adenoma, but not between benign and malignant conditions
- Evaluate the parathyroid in patients with severe hypercalcemia or in patients before parathyroidectomy

RESULT:

Normal findings in:

- No areas of increased perfusion or uptake in the thyroid or parathyroid

Abnormal findings in:

- Intrinsic and extrinsic parathyroid adenomas

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Ingestion of foods containing iodine (e.g., iodized salt) and medications containing iodine (e.g., cough syrup, potassium iodide, vitamins, Lugol's solution, thyroid replacement medications), which can decrease uptake of the radionuclide
- Other nuclear scans or iodinated contrast medium radiographic studies done within the previous 24 to 48 hr

- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Improper injection of the radionuclide that allows the tracer to seep deep into the muscle tissue produces erroneous hot spots.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the parathyroid glands.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodinated contrast medium or radioactive nuclides.
- ▶ Obtain a history of results of the patient's endocrine and immune systems, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test. Inform the patient that the procedure is performed in a nuclear medicine department, usually by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Technetium-99m (Tc-99m) pertechnetate is injected IV before scanning.
- ▶ Place the patient in a supine position under a radionuclide gamma camera. Images are performed 15 min after the injection.
- ▶ With the patient in the same position, Tc-99m sestamibi is injected, and a second image is obtained after 10 min.
- ▶ Iodine-123 may be administered orally in place of Tc-99m pertechnetate; the

imaging sequence, as described previously, is performed 24 hr later.

- Remove the needle and apply a pressure dressing over the puncture site.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- Instruct the patient in the care and assessment of the injection site.
- Advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Tell the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- Instruct the patient to flush the toilet immediately and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.

- Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include calcitonin, calcium, CT thoracic and MRI chest, PTH, phosphorus, and US thyroid and parathyroid.
- Refer to the Endocrine and Immune System tables in the back of the book for related tests by body system.

Partial Thromboplastin Time, Activated

SYNONYM/ACRONYM: aPTT, APTT.

SPECIMEN: Plasma (1 mL) collected in a completely filled blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Clot detection) 25 to 39 sec. Reference ranges vary with respect to the equipment and reagents used to perform the assay.

DESCRIPTION: The activated partial thromboplastin time (aPTT) coagulation test evaluates the function of the intrinsic (factors XII, XI, IX, and VIII) and common (factors V, X, II, and I) pathways of the coagulation sequence, specifically the intrinsic thromboplastin system. It represents the time required for a firm fibrin clot to form after tissue thromboplastin or phospholipid reagents similar to thromboplastin and calcium are added to the specimen. The aPTT is abnormal in 90% of patients with coagulation disorders and is useful in monitoring the inactivation of factor II effect of heparin therapy. The test is prolonged when there is a 30% to 40% deficiency in one of the factors required, or when factor inhibitors (e.g., antithrombin III, protein C, or protein S) are present. The aPTT has additional activators, such as kaolin, Celite, or elegiac acid, that more rapidly activate factor XII, making this test faster and more reliably reproducible than the partial thromboplastin time (PTT). A comparison between the results of aPTT and prothrombin time (PT) tests can allow some inferences to be made that a factor deficiency exists. A normal aPTT with a prolonged PT can only occur with factor VII deficiency. A prolonged aPTT with a normal PT could indicate a deficiency in factors XII, XI, IX, VIII, and VIII:C (von Willebrand factor). Factor deficiencies can also be identified by correction or substitution studies using normal serum. These studies are easy to perform and are accomplished by adding plasma from a normal

patient to a sample from a patient suspected to be factor deficient. When the aPTT is repeated and is corrected, or within the reference range, it can be assumed that the prolonged aPTT is caused by a factor deficiency. If the result remains uncorrected, the prolonged aPTT is most likely due to a circulating anticoagulant. The administration of prophylactic low-dose heparin does not require serial monitoring of aPTT. (For more information on factor deficiencies, see monograph titled "Fibrinogen.")

INDICATIONS:

- Detect congenital deficiencies in clotting factors, as seen in diseases such as hemophilia A (factor VIII) and hemophilia B (factor IX)
- Evaluate response to anticoagulant therapy with heparin or coumarin derivatives
- Identify individuals who may be prone to bleeding during surgical, obstetric, dental, or invasive diagnostic procedures
- Identify the possible cause of abnormal bleeding, such as epistaxis, hematoma, gingival bleeding, hematuria, and menorrhagia
- Monitor the hemostatic effects of conditions such as liver disease, protein deficiency, and fat malabsorption

RESULT:

Prolonged in:

- Afibrinogenemia (***Fibrinogen is required for clotting and its absence will prolong aPTT***)
- Circulating anticoagulants (***Inhibitors of specific factors,***

e.g., developed from long-term Factor VIII therapy or circulating anticoagulants associated with conditions like TB, SLE, RA, and chronic glomerulonephritis)

- Circulating products of fibrin and fibrinogen degradation (**Breakdown products of fibrin in circulation will prolong aPTT**)
- Disseminated intravascular coagulation (**Clotting factors are consumed and aPTT is prolonged**)
- Factor deficiencies (**Factors are required for clotting; in their absence aPTT will be prolonged**)
- Hemodialysis patients (**Heparin will prolong aPTT**)
- Severe liver disease (**Clotting factors are made in the liver; decreased liver function will result in decreased production of clotting factors and prolonged aPTT**)
- Vitamin K deficiency (**Vitamin K is required for clotting and its absence will prolong aPTT**)
- Von Willebrand's disease (**Congenital deficiency of clotting factors that results in prolonged aPTT**)

CRITICAL VALUES:

Greater than 70 seconds.

The requesting health care provider (HCP) should also be notified if the aPTT is less than 53 sec in a patient receiving heparin therapy. Low values indicate that the therapy is providing inadequate anticoagulation.

Note and immediately report to the HCP any critically increased or decreased values and related symptoms. Important signs to note are prolonged bleeding, hematoma at the puncture site, hemorrhage, blood in the stool, bleeding gums, and

shock. Monitoring vital signs and neurological changes until values are within normal range is indicated. Administration of protamine sulfate may be requested.

INTERFERING FACTORS:

- Drugs and vitamins such as anistreplase, antihistamines, chlorpromazine, salicylates, and ascorbic acid may cause prolonged aPTT.
- Anticoagulant therapy with heparin will prolong the aPTT.
- Copper is a component of factor V, and severe copper deficiencies may result in prolonged aPTT values.
- Traumatic venipunctures can activate the coagulation sequence by contamination of the sample with tissue thromboplastin and can produce falsely shortened results.
- Failure to fill the tube sufficiently to yield a proper blood-to-anticoagulant ratio invalidates the results and is reason for specimen rejection.
- Excessive agitation that causes sample hemolysis can falsely shorten the aPTT because the hemolyzed cells activate plasma-clotting factors.
- Inadequate mixing of the tube can produce erroneous results.
- Specimens left unprocessed for longer than 4 hr should be rejected for analysis.
- High platelet count or inadequate centrifugation will result in decreased values.
- Hematocrit greater than 55% may cause falsely prolonged results because of anticoagulant excess. The excess anticoagulant chelates the calcium reagent in the test system, making it unavailable to react properly with the patient sample.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate coagulation disorders and monitor therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's respiratory system, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. If the patient is receiving anticoagulant therapy, note the time and amount of the last dose.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of

collection. Perform a venipuncture. Fill the tube completely. *Important note:* Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%.

- ▶ Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range.
- ▶ When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with tissue thromboplastin.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed specimens stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to report severe bruising or bleeding from any areas of the skin or mucous membranes.
- ▶ Inform the patient with prolonged aPTT values of the importance of taking precautions against bruising and bleeding, including the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of acetylsalicylic acid and similar products, and avoidance of intramuscular injections.
- ▶ Inform the patient of the importance of periodic laboratory testing while taking an anticoagulant.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address

any concerns voiced by the patient or family.

- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include antithrombin III, bleeding time, coagulation factors, complete blood count, complete blood count, platelet count, copper, D-dimer, FDP, plasminogen, protein C, protein S, PT/INR, and vitamin K.
- Refer to the Hematopoietic and Hepatobiliary System tables at the back of the book for related tests by body system.

Parvovirus B19 Immunoglobulin G and Immunoglobulin M Antibodies

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (2 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Negative	Less than 0.8
Equivocal	0.8–1.2

DESCRIPTION: Parvovirus B19, a single-stranded DNA virus transmitted by respiratory secretions, is the only parvovirus known to infect humans. Its primary site of replication is in red blood cell precursors in the bone marrow. It is capable of causing disease along a wide spectrum ranging from a self-limited erythema (fifth disease) to bone marrow failure or aplastic crisis in patients with sickle cell anemia, spherocytosis, or thalassemia. Fetal hydrops and spontaneous abortion may also occur as a result of infection during pregnancy. The incubation period is approximately 1 wk after exposure. B19-specific antibodies

appear in the serum approximately 3 days after the onset of symptoms. The presence of immunoglobulin M (IgM) antibodies indicates acute infection. The presence of immunoglobulin G (IgG) antibodies indicates past infection and is believed to confer lifelong immunity. Parvovirus B19 can also be detected by DNA hybridization using a polymerase chain reaction.

INDICATIONS:

- Assist in establishing a diagnosis of parvovirus B19 infection

RESULT:

Positive findings in:

Parvovirus infection can be evidenced in a variety of conditions.

- Arthritis
- Erythema infectiosum (fifth disease)

Access additional resources at davisplus.fadavis.com

- Erythrocyte aplasia
- Hydrops fetalis

Negative findings in:

CRITICAL VALUES:

Greater than 60 sec

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms. Important signs to note are prolonged bleeding from cuts or gums, hematoma at a puncture site, hemorrhage, blood in the stool, persistent epistaxis, heavy or prolonged menstrual flow, and shock. Monitor vital signs, unusual ecchymosis, occult blood, severe headache, unusual dizziness, and neurological changes until aPTT is within normal range.

INTERFERING FACTORS:

- Immunocompromised patients may not develop sufficient antibody to be detected.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in confirming past or present parvovirus infection.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Inform the patient that a subsequent sample will be required in 7 to 14 days. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle, and apply a pressure dressing over the puncture site.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to lack of neuromuscular control, perceived loss of independence, and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Emphasize the need for the patient to return to have a convalescent blood sample taken in 7 to 14 days. Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include biopsy bone marrow, complete blood count, complete blood count, RBC morphology, and WBC count and differential.
- Refer to the Immune System table at the back of the book for related tests by body system.

Pericardial Fluid Analysis

SYNONYM/ACRONYM: None.

SPECIMEN: Pericardial fluid (5 mL) collected in a red- or green-top (heparin) tube for glucose, a lavender-top (EDTA) tube for cell count, and sterile containers for microbiology specimens; 200 to 500 mL of fluid in a clear container for cytology. Ensure that there is an equal amount of fixative and fluid in the container for cytology.

REFERENCE VALUE: (Method: Spectrophotometry for glucose; automated or manual cell count, macroscopic examination of cultured organisms, and microscopic examination of specimen for microbiology and cytology; microscopic examination of cultured microorganisms)

Pericardial Fluid	Reference Value
Appearance	Clear
Color	Pale yellow
Glucose	Parallels serum values
Red blood cell count	None seen
White blood cell count	Less than 1000/mm ³
Culture	No growth
Gram stain	No organisms seen
Cytology	No abnormal cells seen

DESCRIPTION: The heart is located within a protective membrane called the *pericardium*. The fluid between the pericardial membranes is called *serous fluid*. Normally only a small amount of fluid is present because the rates of fluid production and absorption

are about the same. Many abnormal conditions can result in the buildup of fluid within the pericardium. Specific tests are usually ordered in addition to a common battery of tests used to distinguish a transudate from an exudate. *Transudates* are effusions that form as a

result of a systemic disorder that disrupts the regulation of fluid balance, such as a suspected perforation. *Exudates* are caused by conditions involving the tissue of the membrane itself, such as

an infection or malignancy. Fluid is withdrawn from the pericardium by needle aspiration and tested as listed in the previous and following tables.

Characteristic	Transudate	Exudate
Appearance	Clear	Cloudy or turbid
Specific gravity	Less than 1.015	Greater than 1.015
Total protein	Less than 2.5 g/dL	Greater than 3.0 g/dL
Fluid-to-serum protein ratio	Less than 0.5	Greater than 0.5
LDH	Parallels serum value	Less than 200 units/L
Fluid-to-serum LDH ratio	Less than 0.6	Greater than 0.6
Fluid cholesterol	Less than 55 mg/dL	Greater than 55 mg/dL
White blood cell count	Less than 100/mm ³	Greater than 1000/mm ³

LDH = lactate dehydrogenase.

INDICATIONS:

- Evaluate effusion of unknown etiology
- Investigate suspected hemorrhage, immune disease, malignancy, or infection

RESULT:

Increased in:

Increased in (condition/test showing increased result):

- Bacterial pericarditis (red blood cell [RBC] count, white blood cell [WBC] count with a predominance of neutrophils)
- Hemorrhagic pericarditis (RBC count, WBC count)
- Malignancy (RBC count, abnormal cytology)
- Post-myocardial infarction syndrome, also called Dressler's syndrome (RBC count, WBC count with a predominance of neutrophils)
- Rheumatoid disease or systemic lupus erythematosus (SLE) (RBC count, WBC count)
- Tuberculous or fungal pericarditis (RBC count, WBC count with a predominance of lymphocytes)

- Viral pericarditis (RBC count, WBC count with a predominance of neutrophils)

Decreased in:

Decreased in (condition/test showing decreased result):

- Bacterial pericarditis (glucose)
- Malignancy (glucose)
- Rheumatoid disease or SLE (glucose)

CRITICAL VALUES:

Note and immediately report to the health care provider (HCP) positive culture results, if ordered, and related symptoms.

INTERFERING FACTORS:

- Bloody fluid may be the result of a traumatic tap.
- Unknown hyperglycemia or hypoglycemia may be misleading in the comparison of fluid and serum glucose levels. Therefore, it is advisable to collect comparative serum samples a few hr before performing pericardiocentesis.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to classify the type of effusion being produced and identify the cause of its accumulation.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's respiratory system, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to the surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to needle insertion through the chest wall. Explain to the patient that any discomfort with the needle insertion will be minimized with local anesthetics and systemic analgesics. Explain that the anesthetic injection may cause a stinging sensation. Explain that, after the skin has been anesthetized, a large needle will be inserted through the chest to obtain the fluid. Inform the patient that specimen collection is performed by a HCP specializing in this procedure and it usually takes approximately 30 min to complete.

- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, antibiotics, anesthetics, and analgesics.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Food and fluids should be restricted for 6 to 8 hr before the procedure, as directed by the HCP, unless the procedure is performed in an emergency situation to correct pericarditis. The requesting HCP may request that anticoagulants and aspirin be withheld. The number of days to withhold medication is dependent on the type of anticoagulant. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and fluids restrictions; assure that food has been restricted for at least 6 to 8 hr prior to the procedure.
- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Notify HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Have the patient void before the procedure.
- ▶ Have the patient remove clothes above the waist and put on a gown.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the

corresponding patient demographics, date and time of collection, and site location.

- ▶ Establish an IV line to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.
- ▶ Assist the patient into a comfortable supine position with the head elevated 45° to 60°.
- ▶ Prior to the administration of local anesthesia, cleanse the site with an antiseptic solution, and drape the area with sterile towels. The skin at the injection site is then anesthetized.
- ▶ The precordial (V) cardiac lead wire is attached to the cardiac needle with an alligator clip. The cardiac needle is inserted just below and to the left of the breastbone, and fluid is removed.
- ▶ Monitor vital signs every 15 min for signs of hypovolemia or shock. Monitor electrocardiogram for needle-tip positioning to indicate accidental puncture of the right atrium.
- ▶ The needle is withdrawn, and slight pressure is applied to the site. Apply a sterile dressing to the site.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ▶ Place samples in properly labeled specimen containers, and promptly transport the specimens to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and medications, as directed by the HCP.
- ▶ Monitor vital signs and cardiac status every 15 min for the first hour, every 30 min for the next 2 hr, every hr for the next 4 hr, and every 4 hr for the next 24 hr. Take the patient's temperature every 4 hr for 24 hr. Monitor intake and output for 24 hr. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe the patient for signs of respiratory and cardiac distress, such as shortness of breathe, cyanosis, or rapid pulse.

- ▶ Continue IV fluids until vital signs are stable and the patient can resume fluid intake independently.
- ▶ Inform the patient that 1 hr or more of bed rest is required after the procedure.
- ▶ Assess the puncture site for bleeding or drainage and signs of inflammation each time vital signs are taken and daily thereafter for several days. Report to HCP if bleeding is present.
- ▶ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ▶ Administer antibiotics, as ordered, and instruct the patient in the importance of completing the entire course of antibiotic therapy even if no symptoms are present.
- ▶ Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services, if appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include AST, atrial natriuretic peptide, blood gases, B-type natriuretic peptide, cancer antigens, CEA and cancer antigens, chest x-ray, complete blood count, WBC count and differential, CK and isoenzymes, culture and smear mycobacteria, culture blood, culture fungal, culture viral, ECG, echocardiography, α_1 -fetoprotein, homocysteine, LDH and isoenzymes, magnesium, MRI chest, MI scan, myoglobin, and troponin.
- ▶ Refer to the Cardiovascular and Immune System tables at the back of the book for related tests by body system.

Peritoneal Fluid Analysis

SYNONYM/ACRONYM: Ascites fluid analysis.

SPECIMEN: Peritoneal fluid (5 mL) collected in a red- or green-top (heparin) tube for amylase, glucose, and alkaline phosphatase; lavender-top (EDTA) tube for cell count; sterile containers for microbiology specimens; 200 to 500 mL of fluid in a clear container with anticoagulant for cytology. Ensure that there is an equal amount of fixative and fluid in the container for cytology.

REFERENCE VALUE: (Method: Spectrophotometry for glucose, amylase, and alkaline phosphatase; automated or manual cell count, macroscopic examination of cultured organisms, and microscopic examination of specimen for microbiology and cytology; microscopic examination of cultured microorganisms)

Peritoneal Fluid	Reference Value
Appearance	Clear
Color	Pale yellow
Amylase	Parallels serum values
Alkaline phosphatase	Parallels serum values
Glucose	Parallels serum values
Red blood cell count	Less than 100,000/mm ³
White blood cell count	Less than 300/mm ³
Culture	No growth
Acid-fast stain	No organisms seen
Gram stain	No organisms seen
Cytology	No abnormal cells seen

DESCRIPTION: The peritoneal cavity and organs within it are lined with a protective membrane. The fluid between the membranes is called *serous fluid*. Normally only a small amount of fluid is present because the rates of fluid production and absorption are about the same. Many abnormal conditions can result in the buildup of fluid within the peritoneal cavity. Specific tests are usually ordered in addition to a common battery of tests used to distinguish a transudate from an exudate. *Transudates* are effusions that form as a result of a systemic disorder that

disrupts the regulation of fluid balance, such as a suspected perforation. *Exudates* are caused by conditions involving the tissue of the membrane itself, such as an infection or malignancy. Fluid is withdrawn from the peritoneal cavity by needle aspiration and tested as listed in the previous and following tables.

INDICATIONS:

- Evaluate ascites of unknown cause
- Investigate suspected peritoneal rupture, perforation, malignancy, or infection

Characteristic	Transudate	Exudate
Appearance	Clear	Cloudy or turbid
Specific gravity	Less than 1.015	Greater than 1.015
Total protein	Less than 2.5 g/dL	Greater than 3.0 g/dL
Fluid-to-serum protein ratio	Less than 0.5	Greater than 0.5
LDH	Parallels serum value	Less than 200 units/L
Fluid-to-serum LDH ratio	Less than 0.6	Greater than 0.6
Fluid cholesterol	Less than 55 mg/dL	Greater than 55 mg/dL
White blood cell count	Less than 100/mm ³	Greater than 1000/mm ³

LDH = lactate dehydrogenase.

RESULT:

Increased in:

Increased in (condition/test showing increased result):

- Abdominal malignancy (red blood cell [RBC] count, carcinoembryonic antigen, abnormal cytology)
- Abdominal trauma (RBC count greater than 100,000/mm³)
- Ascites caused by cirrhosis (white blood cell [WBC] count, neutrophils greater than 25% but less than 50%, absolute granulocyte count greater than 250/mm³)
- Bacterial peritonitis (WBC count, neutrophils greater than 50%, absolute granulocyte count greater than 250/mm³)
- Peritoneal effusion due to gastric strangulation, perforation, or necrosis (amylase, ammonia, alkaline phosphatase)
- Peritoneal effusion due to pancreatitis, pancreatic trauma, or pancreatic pseudocyst (amylase)
- Rupture or perforation of urinary bladder (ammonia, creatinine, urea)
- Tuberculous effusion (elevated lymphocyte count, positive acid-fast bacillus smear and culture [25% to 50% of cases])

Decreased in:

Decreased in (condition/test showing decreased result):

- Abdominal malignancy (glucose)
- Tuberculous effusion (glucose)

CRITICAL VALUES:



Note and immediately report to the health care provider (HCP) positive culture results, if ordered, and related symptoms.

INTERFERING FACTORS:

- Bloody fluids may result from a traumatic tap.
- Unknown hyperglycemia or hypoglycemia may be misleading in the comparison of fluid and serum glucose levels. Therefore, it is advisable to collect comparative serum samples a few hr before performing paracentesis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to classify the type of effusion being produced and identify the cause of its accumulation.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's respiratory system, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. If patient has ascites, obtain weight and measure abdominal girth. Inform the patient that it may be necessary to remove hair from the site before the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to needle insertion through the abdomen wall. Explain to the patient that any discomfort with the needle insertion will be minimized with local anesthetics and systemic analgesics. Explain that the anesthetic injection may cause an initial stinging sensation. Explain that, after the skin has been anesthetized, a large needle will be inserted through the abdominal wall and a "popping" sensation may be experienced as the needle penetrates the peritoneum. Inform the patient that specimen collection is performed under sterile conditions by a HCP specializing in this procedure. The procedure usually takes approximately 30 min to complete.
- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, antibiotics, anesthetics, and analgesics.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction. The requesting HCP may request that anticoagulants and aspirin be withheld. The number of days to withhold medication is dependent on the type of anticoagulant.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available.
- ▶ Have the patient void or catheterize the patient to avoid accidental puncture of the bladder if he or she is unable to void.
- ▶ Have the patient remove clothing and change into a gown for the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Record baseline vital signs and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Establish an IV line to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.
- ▶ Assist the patient to a comfortable seated position with feet and back supported or in high Fowler's position.
- ▶ Prior to the administration of local anesthesia, shave and cleanse the site with an antiseptic solution, and drape the area with sterile towels. The skin at the injection site is then anesthetized.
- ▶ The paracentesis needle is inserted 1 to 2 in. below the umbilicus, and fluid is removed. If lavage fluid is required (helpful if malignancy is suspected), saline or Ringer's lactate can be infused via the needle over a 15- to 20-min period before the lavage fluid is removed. Monitor vital signs every 15 min for signs of hypovolemia or shock.

- ▶ No more than 1500 to 2000 mL of fluid should be removed at a time, even in the case of a therapeutic paracentesis, because of the risk of hypovolemia and shock.
- ▶ The needle is withdrawn, and slight pressure applied to the site. Apply a sterile dressing to the site.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ▶ Place samples in properly labeled specimen containers, and promptly transport the specimens to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications, as directed by the HCP.
- ▶ Monitor vital signs every 15 min for the first hr, every 30 min for the next 2 hr, every hour for the next 4 hr, and every 4 hr for the next 24 hr. Take the patient's temperature every 4 hr for 24 hr. Monitor intake and output for 24 hr. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Assess the puncture site for bleeding or drainage and signs of inflammation each time vital signs are taken and daily thereafter for several days. Report to HCP if bleeding is present.
- ▶ If a large amount of fluid was removed, obtain weight and measure abdominal girth.
- ▶ Inform the patient that 1 hr or more of bed rest is required after the procedure.
- ▶ Instruct the patient to immediately report severe abdominal pain (*Note:* rigidity of abdominal muscles indicates developing peritonitis).

Report to HCP if abdominal rigidity or pain is present.

- ▶ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ▶ Administer antibiotics, as ordered, and instruct the patient in the importance of completing the entire course of antibiotic therapy even if no symptoms are present.
- ▶ Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services, if appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CEA and cancer antigens, complete blood count, complete blood count, WBC count and differential, CT abdomen, CT biliary tract and liver, culture and smear mycobacteria, culture blood, culture fungal, culture viral, KUB studies, laparoscopy abdominal, liver and spleen scan, MRI abdomen, and US spleen.
- ▶ Refer to the Gastrointestinal and Immune System tables at the back of the book for related tests by body system.

Phosphorus, Blood

SYNONYM/ACRONYM: Inorganic phosphorus, phosphate, PO₄

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 0.323)
0–5 d	4.6–8.0 mg/dL	1.5–2.6 mmol/L
1–3 yr	3.9–6.5 mg/dL	1.3–2.1 mmol/L
4–6 yr	4.0–5.4 mg/dL	1.3–1.7 mmol/L
7–11 yr	3.7–5.6 mg/dL	1.2–1.8 mmol/L
12–13 yr	3.3–5.4 mg/dL	1.1–1.7 mmol/L
14–15 yr	2.9–5.4 mg/dL	0.9–1.7 mmol/L
16–19 yr	2.8–4.6 mg/dL	0.9–1.5 mmol/L
Adult	2.5–4.5 mg/dL	0.8–1.4 mmol/L

DESCRIPTION: Phosphorus, in the form of phosphate, is distributed throughout the body. Approximately 85% of the body's phosphorus is stored in bones; the remainder is found in cells and body fluids. It is the major intracellular anion and plays a crucial role in cellular metabolism, maintenance of cellular membranes, and formation of bones and teeth. Phosphorus also indirectly affects the release of oxygen from hemoglobin by affecting the formation of 2,3-bisphosphoglycerate. Levels of phosphorus are dependent on dietary intake.

Phosphorus excretion is regulated by the kidneys. Calcium and phosphorus are interrelated with respect to absorption and metabolic function. They have an inverse relationship with respect to concentration: serum phosphorus is increased when serum

calcium is decreased. Hyperphosphatemia can result in an infant fed only cow's milk during the first few weeks of life because of the combination of a high phosphorus content in cow's milk and the inability of infants' kidneys to clear the excess phosphorus.

INDICATIONS:

- Assist in establishing a diagnosis of hyperparathyroidism
- Assist in the evaluation of renal failure

RESULT:

Increased in:

- Acromegaly (**Related to increased renal absorption**)
- Bone metastases (**Related to release from bone stores**)
- Diabetic ketoacidosis (**Acid base imbalance that causes intracellular**

phosphorus to move into the extracellular fluid)

- Excessive levels of vitamin D (**Vitamin D promotes intestinal absorption of phosphorus; excessive levels promote phosphorus release from bone stores**)
- Hyperthermia (**Tissue damage causes intracellular phosphorus to be released into circulation**)
- Hypocalcemia (**Calcium and phosphorus have an inverse relationship**)
- Hypoparathyroidism (**Related to increased renal absorption**)
- Lactic acidosis (**Acid-base imbalance causes intracellular phosphorus to move into the extracellular fluid**)
- Milk alkali syndrome (**Increased dietary intake**)
- Pseudohypoparathyroidism (**Related to increased renal absorption**)
- Pulmonary embolism (**Related to respiratory acid-base imbalance and compensatory mechanisms**)
- Renal failure (**Related to decreased renal excretion**)
- Respiratory acidosis (**Acid-base imbalance that causes intracellular phosphorus to move into the extracellular fluid**)

Decreased in:

- Acute gout
- Alcohol withdrawal
- Gram-negative bacterial septicemia
- Growth hormone deficiency
- Hyperalimentation therapy
- Hypercalcemia (**Calcium and phosphorus have an inverse relationship**)
- Hyperinsulinism (**Insulin increases intracellular movement of phosphorus**)
- Hyperparathyroidism (**PTH increases renal excretion**)
- Hypokalemia

- Impaired renal absorption (**Decreases return of phosphorus to general circulation**)
- Malabsorption syndromes (**Insufficient intestinal absorption of phosphorus**)
- Malnutrition (**Deficient intake**)
- Osteomalacia
- Parathyroid hormone-producing tumors (**PTH increases renal excretion**)
- Primary hyperparathyroidism (**PTH increases renal excretion**)
- Renal tubular acidosis
- Renal tubular defects (**Decreased renal absorption**)
- Respiratory alkalosis
- Respiratory infections
- Rickets (**Related to vitamin D deficiency**)
- Salicylate poisoning
- Severe burns
- Severe vomiting and diarrhea (**Excessive loss**)
- Vitamin D deficiency (**Deficiency in vitamin D reduces intestinal and renal tubular absorption of phosphorus**)

CRITICAL VALUES: 

Values less than 1.0 mg/dL may have significant effects on the neuromuscular, gastrointestinal (GI), cardiopulmonary, and skeletal systems.

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms. Interventions including IV replacement therapy with sodium or potassium phosphate may be necessary. Close monitoring of both phosphorus and calcium is important during replacement therapy.

INTERFERING FACTORS:

- Drugs that may increase phosphorus levels include anabolic steroids, β -adrenergic blockers, ergocalciferol, furosemide, hydrochlorothiazide, methicillin (occurs with nephrotoxicity), oral

contraceptives, parathyroid extract, phosphates, sodium etidronate, tetracycline (occurs with nephrotoxicity), and vitamin D.

- Drugs that may decrease phosphorus levels include acetazolamide, albuterol, aluminum salts, amino acids (via IV hyperalimentation), anesthetic agents, anticonvulsants, calcitonin, epinephrine, fibrin hydrolysate, fructose, glucocorticoids, glucose, insulin, mannitol, oral contraceptives, pamidronate, phenothiazine, phytate, and plicamycin.
- Serum phosphorus levels are subject to diurnal variation: They are highest in late morning and lowest in the evening; therefore, serial samples should be collected at the same time of day for consistency in interpretation.
- Hemolysis will falsely increase phosphorus values.
- Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, thereby falsely decreasing the result. There is also the potential of contaminating the sample with the substance of interest, if it is present in the IV solution, thereby falsely increasing the result.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the general evaluation of multiple body systems.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ♦ Obtain a history of the patient's endocrine, GI, genitourinary, and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ♦ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient demographic, date, and time of collection. Perform a venipuncture.
- ♦ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ♦ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ♦ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ♦ **Nutritional considerations:** Severe hypophosphatemia is common in elderly patients or patients who have been hospitalized for long periods of time. Good dietary sources of phosphorus include meat, dairy products, nuts, and legumes.

- ▶ **Nutritional considerations:** To decrease phosphorus levels to normal in the patient with hyperphosphatemia, dietary restriction may be recommended. Other interventions may include the administration of phosphate binders or administration of calcitriol (the activated form of vitamin D).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation

to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone, blood gases, BUN, calcitonin, calcium, calculus kidney stone panel, carbon dioxide, chloride, collagen cross-linked N-telopeptides, complete blood count, WBC count and differential, creatinine, fecal analysis, fecal fat, FDP, glucagon, glucose, GH, insulin, lactic acid, lung perfusion scan, lung ventilation scan, osmolality, osteocalcin, PTH, parathyroid scan, phosphorus urine, potassium, and vitamin D.
- ▶ Refer to the Endocrine, Gastrointestinal, Genitourinary, and Musculoskeletal System tables at the back of the book for related tests by body system.

Phosphorus, Urine

SYNONYM/ACRONYM: Urine phosphate.

SPECIMEN: Urine (5 mL) from an unpreserved random or timed specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Spectrophotometry) Reference values are dependent on phosphorus and calcium intake. Phosphate excretion exhibits diurnal variation and is significantly higher at night.

P

Conventional Units

0.4–1.3 g/24 hr

SI Units (Conventional Units × 32.3)

12.9–42.0 g/24 hr

DESCRIPTION: Phosphorus, in the form of phosphate, is distributed throughout the body. Approximately 85% of the body's phosphorus is stored in bones; the remainder is found in cells and body fluids. It is the major

intracellular anion and plays a crucial role in cellular metabolism, maintenance of cellular membranes, and formation of bones and teeth. Phosphorus also indirectly affects the release of oxygen from hemoglobin by

affecting the formation of 2,3-bisphosphoglycerate. Levels of phosphorus are dependent on dietary intake.

Analyzing urinary phosphorus levels can provide important clues to the functioning of the kidneys and other major organs. Tests for phosphorus in urine usually involve timed urine collections over a 12- or 24-hr period. Measurement of random specimens may also be requested. Children with thalassemia may have normal phosphorus absorption but increased excretion, which may result in a phosphorus deficiency.

INDICATIONS:

- Assist in the diagnosis of hyperparathyroidism
- Assist in the evaluation of calcium and phosphorus balance
- Assist in the evaluation of nephrolithiasis
- Assist in the evaluation of renal tubular disease

RESULT:

Increased in:

- Abuse of diuretics (**Increased renal excretion**)
- Primary hyperparathyroidism (**PTH increases renal excretion**)
- Renal tubular acidosis
- Vitamin D deficiency (**Decreased renal reabsorption**)

Decreased in:

- Hypoparathyroidism (**PTH enhances renal excretion, therefore a lack of PTH will decrease urine phosphorus levels**)
- Pseudohypoparathyroidism (**PTH enhances renal reabsorption, therefore a lack of response to PTH as in pseudohypoparathy-**

roidism will decrease urine phosphorus levels)

- Vitamin D intoxication (**Vitamin D promotes renal excretion of phosphorus**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and vitamins that can cause an increase in urine phosphorus levels include acetazolamide, acetylsalicylic acid, alanine, bismuth salts, calcitonin, corticosteroids, dihydrotachysterol, glycine, hydrochlorothiazide, metolazone, parathyroid extract, parathyroid hormone, phosphates, tryptophan, valine, and vitamin D.
- Drugs that can cause a decrease in urine phosphorus levels include aluminum-containing antacids.
- Urine phosphorus levels are subject to diurnal variation: Output is highest in the afternoon, which is why 24-hr urine collections are recommended.
- All urine voided for the timed collection period must be included in the collection or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate calcium and phosphorus balance.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and genitourinary systems,

symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to avoid excessive exercise and stress during the 24-hr collection of urine.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with activity restrictions and pretesting preparations; assure that excessive exercise and stress have been restricted during the 24-hr procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container

system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.

- At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that can affect test results.

General:

- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Nutritional considerations:** Vitamin D is necessary for the body to absorb phosphorus. Vitamin D is added to food products such as milk, cheese, and orange juice. The recommended daily intake of vitamin D is 200 IU per day for men and women under 50, and 400 for men and women over 50 y.o.

- Increased urine phosphorus levels may be associated with the formation of kidney stones. Educate the patient, if appropriate, on the importance of drinking a sufficient amount of water when kidney stones are suspected.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ALP, calcitonin, calcium, calculus kidney stone panel, chloride, CT abdomen, cystoscopy, IVP, KUB studies, PTH, parathyroid scan, phosphorus blood, potassium, renogram, retrograde ureteropyelography, uric acid, and UA.
- Refer to the Endocrine and Genitourinary System tables at the back of the book for related tests by body system.

Plasminogen

SYNONYM/ACRONYM: Profibrinolysin, PMG.

SPECIMEN: Plasma (1 mL) collected in blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Chromogenic substrate) 80% to 120% of normal for plasma.

DESCRIPTION: Plasminogen is a plasma glycoprotein. It is the circulating, inactive precursor to plasmin. Damaged tissues release a substance called *plasminogen activator* that initiates the conversion of plasminogen to plasmin. Plasmin participates in fibrinolysis and is capable of degrading fibrin, factor I (fibrinogen), factor V, and factor VIII. (For more information on fibrin degradation, see monograph titled “Fibrinogen.”)

INDICATIONS:

Evaluate the level of circulating plasminogen in patients with thrombosis or disseminated intravascular coagulation (DIC).

RESULT:

Increased in:

- Pregnancy (late) (*Pathophysiology is not well understood*)

Decreased in:

- DIC (*Levels decrease as it is consumed during the hyperfibrinolytic state by conversion to plasmin*)
- Fibrinolytic therapy with tissue plasminogen activators such as streptokinase or urokinase (*Levels decrease as it is consumed during the therapy by conversion to plasmin*)
- Hereditary deficiency
- Liver disease (*Related to decreased production by damaged liver cells*)
- Neonatal hyaline membrane disease (*Possibly related to deficiency of plasminogen*)
- Postsurgical period (*Possibly related to trauma of surgery*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Drugs that may decrease plasminogen levels include streptokinase and urokinase.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate thrombotic disorders and monitor thrombolytic therapy.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ♦ Observe standard precautions and follow the general guidelines in Appendix A. Positively identify the

patient and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. *Important note:* Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range.

- ▶ When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with tissue thromboplastin, which can falsely decrease values.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed samples stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection. If the patient has a known hematocrit above 55%,

adjust the amount of anticoagulant in the collection tube before drawing the blood according to the CLSI guidelines:

$$\text{Anticoagulant vol. [x]} = (100 - \text{hematocrit}) / (595 - \text{hematocrit}) \times \text{total vol. of anticoagulated blood required}$$

Example:

$$\text{Patient hematocrit} = 60\% \quad (100 - 60) / (595 - 60) \times 5.0 = 0.37 \text{ mL sodium citrate for a 5 mL standard drawing tube}$$

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include AT-III, complete blood count, platelet count, coagulation factors, FDP, fibrinogen, aPTT, protein S, and PT/INR.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Platelet Antibodies

SYNONYM/ACRONYM: Antiplatelet antibody; platelet-bound IgG/IgM, direct and indirect.

SPECIMEN: Serum (1 mL) collected in a red-top tube for indirect immunoglobulin G (IgG) antibody. Whole blood (7 mL) collected in lavender-top (EDTA) tube for direct antibody.

REFERENCE VALUE: (Method: Solid-phase hemagglutination and flow cytometry) Negative.

DESCRIPTION: Platelet antibodies can be formed by autoimmune response, or they can be acquired in reaction to transfusion products. Platelet autoantibodies are immunoglobulins of autoimmune origin (i.e., immunoglobulin G [IgG]), and they are present in various autoimmune disorders, including thrombocytopenias. Platelet alloantibodies develop in patients who become sensitized to platelet antigens of transfused blood. As a result, destruction of both donor and native platelets occurs along with a shortened survival time of platelets in the transfusion recipient. The platelet antibody detection test is also used for platelet typing, which allows compatible platelets to be transfused to patients with disorders such as aplastic anemia and cancer. Platelet typing decreases the alloimmunization risk resulting from repeated transfusions from random donors. Platelet typing may also provide additional support for a diagnosis of post-transfusional purpura.

- Determine platelet type for refractory patients

RESULT:

Increased in:

Development of platelet antibodies is associated with autoimmune conditions and medications.

- AIDS
- Acute myeloid leukemia
- Idiopathic thrombocytopenic purpura (***Related to development of platelet-associated IgG antibodies***)
- Immune complex diseases
- Multiple blood transfusions (***Related in most cases to sensitization to PLAI antigens on donor red blood cells that will stimulate formation of antiplatelet antibodies***)
- Multiple myeloma
- Neonatal immune thrombocytopenia (***Related to maternal platelet-associated antibodies directed against fetal platelets***)
- Paroxysmal hemoglobinuria
- Rheumatoid arthritis
- Systemic lupus erythematosus
- Thrombocytopenias provoked by drugs (see monograph titled “Complete Blood Count, Platelet Count”)

Decreased in: N/A

CRITICAL VALUES: N/A

INDICATIONS:

- Assist in the detection of platelet alloimmune disorders

INTERFERING FACTORS:

Hemolyzed or clotted specimens will affect results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate thrombocytopenia.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, and inform the appropriate health care provider (HCP) accordingly.
- ▶ Obtain a history of the patient's hematopoietic and immune systems, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Note the patient's response to platelet transfusions.
- ▶ Instruct the patient to report severe bruising or bleeding from any areas of the skin or mucous membranes.
- ▶ Inform the patient who has developed platelet antibodies of the importance of taking precautions against bruising and bleeding, including the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of acetylsalicylic acid and similar products, and avoidance of intramuscular injections.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography abdominal, biopsy bone marrow, bleeding time, clot retraction, complete blood count, platelet count, CT brain, Ham's test, hemosiderin, and LAP.
- ▶ Refer to the Hematopoietic and Immune System tables at the back of the book for related tests by body system.

Plethysmography

SYNONYM/ACRONYM: Impedance plethysmography, PVR.

AREA OF APPLICATION: Veins, arteries, and lungs.

CONTRAST: None.

DESCRIPTION: Plethysmography is a noninvasive diagnostic manometric study used to measure changes in the size of blood vessels by determining volume changes in the blood vessels of the eye, extremities, and neck; or to measure gas volume changes in the lungs.

Arterial plethysmography assesses arterial circulation in an upper or lower limb; it is used to diagnose extremity arteriosclerotic disease and to rule out occlusive disease. The test requires a normal extremity for comparison of results. The test is performed by applying a series of three blood pressure cuffs to the extremity. The amplitude of each pulse wave is then recorded.

Venous plethysmography, done with a series of cuffs, measures changes in venous capacity and outflow (volume and rate of outflow); it is used to diagnose a thrombotic condition that causes obstruction of the major veins of the extremity. When the cuffs are applied to an extremity in patients with venous obstruction, no initial increase in leg volume is recorded because the venous volume of the leg cannot dissipate quickly.

Body plethysmography measures the total amount (volume) of air within the thorax, whether or not the air is in ventilatory communication with the lung; the elasticity (compliance) of the

lungs; and the resistance to airflow in the respiratory tree. It is used in conjunction with pulmonary stress testing and pulmonary function testing.

Impedance plethysmography is widely used to detect acute deep vein thrombosis (DVT) of the leg, but it can also be used in the arm, abdomen, neck, or thorax. Doppler flow studies now are used to identify DVT, but ultrasound studies are less accurate in examinations below the knee.

INDICATIONS:

Arterial Plethysmography:

- Confirm suspected acute arterial embolization
- Detect vascular changes associated with Raynaud's phenomenon and disease
- Determine changes in toe or finger pressures when ankle pressures are elevated as a result of arterial calcifications
- Determine the effect of trauma on the arteries in an extremity
- Determine peripheral small-artery changes (ischemia) caused by diabetes, and differentiate these changes from neuropathy
- Evaluate suspected arterial occlusive disease
- Locate and determine the degree of arterial atherosclerotic obstruction and vessel patency in peripheral atherosclerotic disease, as well

as inflammatory changes causing obliteration in the vessels in thromboangiitis obliterans

Venous Plethysmography:

- Detect partial or total venous thrombotic obstruction
- Determine valve competency in conjunction with Doppler ultrasonography in the diagnosis of varicose veins

Body Plethysmography:

- Detect acute pulmonary disorders, such as atelectasis
- Detect or determine the status of chronic obstructive pulmonary disease (COPD), such as emphysema, asthma, or chronic bronchitis
- Detect or determine the status of restrictive pulmonary disease, such as fibrosis
- Detect infectious pulmonary diseases, such as pneumonia
- Determine baseline pulmonary status before pulmonary rehabilitation to determine potential therapeutic benefit
- Differentiate between obstructive and restrictive pulmonary pathology

Impedance Plethysmography:

- Act as a diagnostic screen for patients at risk for DVT
- Detect and evaluate DVT
- Evaluate degree of resolution of DVT after treatment
- Evaluate patients with suspected pulmonary embolism (most pulmonary emboli are complications of DVT in the leg)

RESULT:

Normal findings in:

- Arterial plethysmography:
Normal arterial pulse waves: steep upslope, more gradual downslope with narrow pointed peaks
Normal pressure: less than 20 mm Hg systolic difference between the lower and upper extremities; toe pressure greater than or equal to 80% of ankle

pressure, and finger pressure greater than or equal to 80% of wrist pressure

- Venous plethysmography:
Normal venous blood flow in the extremities
Venous filling times greater than 20 sec
- Body plethysmography:
Thoracic gas volume: 2400 mL
Compliance: 0.2 L/cm H₂O
Airway resistance: 0.6 to 2.5 cm H₂O/L per sec
- Impedance plethysmography:
Sharp rise in volume with temporary occlusion
Rapid venous outflow with release of the occlusion

Abnormal findings in:

- COPD, restrictive lung disease, lung infection, or atelectasis (body plethysmography)
- DVT (arterial, venous, or impedance plethysmography)
- Incompetent valves, thrombosis, or thrombotic obstruction in a major vein in an extremity
- Small-vessel diabetic changes
- Vascular disease (Raynaud's phenomenon)
- Vascular trauma

CRITICAL VALUES:

- DVT

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS:

Arterial Plethysmography:

Factors that may impair results of the examination:

- Cigarette smoking 2 hr before the study, which causes inaccurate results because the nicotine constricts the arteries
- Alcohol consumption
- Low cardiac output
- Shock

- Compression of pelvic veins (tumors or external compression by dressings)
- Environmental temperatures (hot or cold)
- Arterial occlusion proximal to the extremity to be examined, which can prevent blood flow to the limb

Venous Plethysmography:

Factors that may impair results of the examination:

- Low environmental temperature or cold extremity, which constricts the vessels
- High anxiety level or muscle tenseness
- Venous thrombotic occlusion proximal to the extremity to be examined, which can affect blood flow to the limb

Body Plethysmography:

Factors that may impair results of the examination:

- Inability of the patient to follow breathing instructions during the procedure

Impedance Plethysmography:

Factors that may impair results of the examination:

- Movement of the extremity during electrical impedance recording, poor electrode contact, or nonlinear electrical output, which can cause false-positive results
- Constricting clothing or bandages

- ◆ Inform the patient the test is used to measure changes in blood vessel size or changes in gas volume in the lungs.
- ◆ Obtain a history of the patient's complaints including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ◆ Obtain a history of the patient's cardiovascular and pulmonary systems, symptoms, and results of laboratory tests and diagnostic and surgical procedures.
- ◆ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no discomfort will be experienced during the test. Explain that there may be some discomfort during insertion of the nasoesophageal catheter if compliance testing is done. Inform the patient that the procedure is generally performed in a specialized area or at the bedside by a health care provider (HCP) who specializes in this procedure, with support staff, and usually takes 30 to 60 min.
- ◆ Assess the patient's ability to comply with directions given for rest, positioning, and activity before and during the procedure.
- ◆ For body plethysmography, record the patient's weight, height, and gender. Determine whether the patient is claustrophobic.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during and after the procedure.
- ◆ Instruct the patient to refrain from smoking for 2 hr prior to the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

INTRATEST:

- ◆ Ensure the patient has refrained from smoking for 2 hr before the procedure.
- ◆ Instruct the patient to void prior to the procedure and to change into the

gown, robe, and foot coverings provided.

- ▶ Obtain and record baseline vital signs.
- ▶ Instruct the patient to report any unexpected symptoms that occur during the test.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.

Arterial Plethysmography:

- ▶ Explain to the patient that cuffs are applied to the extremity to measure and compare blood flow.
- ▶ Place the patient in a semi-Fowler position on an examining table or in bed.
- ▶ Ask the patient to notify medical personnel if he or she has unexpected symptoms during the test.
- ▶ Instruct the patient to remain still during the procedure.
- ▶ Apply three blood pressure cuffs to the extremity and attach a pulse volume recorder (plethysmograph), which records the amplitude of each pulse wave.
- ▶ Inflate the cuffs to 65 mm Hg to measure the pulse waves of each cuff. When compared with a normal limb, these measurements determine the presence of arterial occlusive disease.

Venous Plethysmography:

- ▶ Explain to the patient that cuffs are applied to the extremity to measure and compare blood flow.
- ▶ Place the patient in a semi-Fowler position on an examining table or in bed.
- ▶ Instruct the patient to remain still during the procedure.
- ▶ Apply two blood pressure cuffs to the extremity, one on the proximal part of the extremity (occlusion cuff) and the other on the distal part of the extremity (recorder cuff). Attach a third cuff to the pulse volume recorder.
- ▶ Inflate the recorder cuff to 10 mm Hg, and evaluate the effects of respiration on venous volume: Absence of changes during respirations indicates venous thrombotic occlusion.
- ▶ Inflate the occlusion cuff to 50 mm Hg, and record venous volume on the pulse monitor. Deflate the occlusion cuff after the highest volume is recorded in the recorder cuff. A delay in the

return to preocclusion volume indicates venous thrombotic occlusion.

Body Plethysmography:

- ▶ Place the patient in a sitting position on a chair in the body box. Explain to the patient that the cuffs are applied to the extremities to measure and compare blood flow.
- ▶ Position a nose clip to prevent breathing through the nose, and connect a mouthpiece to a measuring instrument.
- ▶ Ask the patient to breathe through the mouthpiece.
- ▶ Close the door to the box, and record the start time of the procedure. At the beginning of the study, instruct the patient to pant rapidly and shallowly, without allowing the glottis to close.
- ▶ For compliance testing, a double-lumen nasoesophageal catheter is inserted, and the bag is inflated with air. Intraesophageal pressure is recorded during normal breathing.

Impedance Plethysmography:

- ▶ Explain to the patient that cuffs are applied to the extremity to measure and compare blood flow.
- ▶ Place the patient on his or her back with the leg being tested above the heart level.
- ▶ Flex the patient's knee slightly, and rotate the hips by shifting weight to the same side as the leg being tested.
- ▶ Apply conductive gel and electrodes to the legs, near the cuffs.
- ▶ Apply a blood pressure cuff to the thigh.
- ▶ Inflate the pressure cuff attached to the thigh temporarily to occlude venous return without interfering with arterial blood flow. Expect the blood volume in the other calf to increase.
- ▶ A tracing of changes in electrical impedance occurring during inflation and for 15 sec after cuff deflation is recorded.
- ▶ With DVT, blood volume increases less than expected because the veins are already at capacity.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Remove conductive gel and electrodes, as applied.

- ▶ Instruct the patient to resume usual activity and diet, as directed by the HCP.
- ▶ Monitor for severe ischemia, ulcers, and pain of the extremity after arterial, venous, or impedance plethysmography, and handle the extremity gently.
- ▶ Monitor respiratory pattern after body plethysmography, and allow the patient time to resume a normal breathing pattern.
- ▶ Monitor vital signs every 15 min until they return to baseline levels.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate

test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include α_1 -AT, angiography pulmonary, anion gap, arterial/alveolar oxygen ratio, AT-III, biopsy lung, blood gases, bronchoscopy, carboxyhemoglobin, cardiolipin antibodies, chest x-ray, chloride sweat, cold agglutinin, complete blood count, complete blood count, hemoglobin, complete blood count, WBC count and differential, CT angiography, CT thoracic, culture and smear for mycobacteria, culture bacterial sputum, culture viral, cytology sputum, D-dimer, echocardiography, ECG, EMG, ENG, fibrinogen, gram stain, IgE, lactic acid, lung perfusion scan, lung ventilation scan, lupus anticoagulant antibodies, MR angiography, MRI chest, osmolality, phosphorus, plasminogen, pleural fluid analysis, potassium, PET chest, PFT, pulse oximetry, sodium, TB skin test, and US arterial and venous Doppler of the extremities.
- ▶ Refer to the Cardiovascular and Pulmonary System table in the back of the book for related tests by body system.

Pleural Fluid Analysis

P

SYNONYM/ACRONYM: Thoracentesis fluid analysis.

SPECIMEN: Pleural fluid (5 mL) collected in a green-top (heparin) tube for amylase, cholesterol, glucose, lactate dehydrogenase (LDH), pH, protein, and triglycerides; lavender-top (EDTA) tube for cell count; sterile containers for microbiology specimens; 200 to 500 mL of fluid in a clear container with anti-coagulant for cytology. Ensure that there is an equal amount of fixative and fluid in the container for cytology.

REFERENCE VALUE: (Method: Spectrophotometry for amylase, cholesterol, glucose, LDH, protein, and triglycerides; ion-selective electrode for pH; automated or manual cell count; macroscopic and microscopic examination of cultured microorganisms; microscopic examination of specimen for microbiology and cytology.)

Appearance	Clear
Color	Pale yellow
Amylase	Parallels serum values
Cholesterol	Parallels serum values
Glucose	Parallels serum values
LDH	Less than 200 units/L
Fluid LDH-to-serum LDH ratio	0.6 or less
Protein	3.0 g/dL
Fluid protein-to-serum protein ratio	0.5 or less
Triglycerides	Parallel serum values
pH	7.37–7.43
RBC count	Less than 1000/mm ³
WBC count	Less than 1000/mm ³
Culture	No growth
Gram stain	No organisms seen
Cytology	No abnormal cells seen

LDH = lactate dehydrogenase; RBC = red blood cell; WBC = white blood cell.

DESCRIPTION: The pleural cavity and organs within it are lined with a protective membrane. The fluid between the membranes is called *serous fluid*. Normally only a small amount of fluid is present because the rates of fluid production and absorption are about the same. Many abnormal conditions can result in the buildup of fluid within the pleural cavity. Specific tests are usually ordered in addition to a common battery of tests used to distinguish a

transudate from an exudate. *Transudates* are effusions that form as a result of a systemic disorder that disrupts the regulation of fluid balance, such as a suspected perforation. *Exudates* are caused by conditions involving the tissue of the membrane itself, such as an infection or malignancy. Fluid is withdrawn from the pleural cavity by needle aspiration and tested as listed in the previous and following tables.

Characteristic	Transudate	Exudate
Appearance	Clear	Cloudy or turbid
Specific gravity	Less than 1.015	Greater than 1.015
Total protein	Less than 2.5 g/dL	Greater than 3.0 g/dL
Fluid protein-to-serum protein ratio	Less than 0.5	Greater than 0.5
LDH	Parallels serum value	Less than 200 units/L
Fluid LDH-to-serum LDH ratio	Less than 0.6	Greater than 0.6
Fluid cholesterol	Less than 55 mg/dL	Greater than 55 mg/dL
WBC count	Less than 1000/mm ³	Greater than 1000/mm ³

LDH = lactate dehydrogenase; WBC = white blood cell.

INDICATIONS:

- Differentiate transudates from exudates
- Evaluate effusion of unknown cause
- Investigate suspected rupture, immune disease, malignancy, or infection

RESULT:

- *Bacterial or tuberculous empyema:* Red blood cell (RBC) count less than $5000/\text{mm}^3$, white blood cell (WBC) count $25,000$ to $100,000/\text{mm}^3$ with a predominance of neutrophils, increased fluid protein-to-serum protein ratio, increased fluid LDH-to-serum LDH ratio, decreased glucose, pH less than 7.3
- *Chylous pleural effusion:* Marked increase in both triglycerides (two to three times serum level) and chylomicrons
- *Effusion caused by pneumonia:* RBC count less than $5000/\text{mm}^3$, WBC count 5000 to $25,000/\text{mm}^3$ with a predominance of neutrophils and some eosinophils, increased fluid protein-to-serum protein ratio, increased fluid LDH-to-serum LDH ratio, pH less than 7.4 (and decreased glucose if bacterial pneumonia)
- *Esophageal rupture:* Significantly decreased pH (6.0) and elevated amylase
- *Hemothorax:* Bloody appearance, increased RBC count, elevated hematocrit
- *Malignancy:* RBC count 1000 to $100,000/\text{mm}^3$, WBC count 5000 to $10,000/\text{mm}^3$ with a predominance of lymphocytes, abnormal cytology, increased fluid protein-to-serum protein ratio, increased fluid LDH-to-serum LDH ratio, decreased glucose, pH less than 7.3
- *Pancreatitis:* RBC count 1000 to $10,000/\text{mm}^3$, WBC count 5000 to $20,000/\text{mm}^3$ with a predominance of neutrophils, pH greater than

7.3, increased fluid protein-to-serum protein ratio, increased fluid LDH-to-serum LDH ratio, increased amylase

- *Pulmonary infarction:* RBC count $10,000$ to $100,000/\text{mm}^3$, WBC count 5000 to $15,000/\text{mm}^3$ with a predominance of neutrophils, pH greater than 7.3, normal glucose, increased fluid protein-to-serum protein ratio, and increased fluid LDH-to-serum LDH ratio.
- *Pulmonary tuberculosis:* RBC count $10,000/\text{mm}^3$, WBC count 5000 to $10,000/\text{mm}^3$ with a predominance of lymphocytes, positive acid-fast bacillus stain and culture, increased protein, decreased glucose, pH less than 7.3
- *Rheumatoid disease:* Normal RBC count, WBC count 1000 to $20,000/\text{mm}^3$ with a predominance of either lymphocytes or neutrophils, pH less than 7.3, decreased glucose, increased fluid protein-to-serum protein ratio, increased fluid LDH-to-serum LDH ratio, increased immunoglobulins
- *Systemic lupus erythematosus:* Similar findings as with rheumatoid disease, except that glucose is usually not decreased

CRITICAL VALUES: 

Note and immediately report to the health care provider (HCP) positive culture results, if ordered, and related symptoms. pH 7.1–7.2 indicates need for immediate drainage.

INTERFERING FACTORS:

- Bloody fluids may be the result of a traumatic tap.
- Unknown hyperglycemia or hypoglycemia may be misleading in the comparison of fluid and serum glucose levels. Therefore, it is advisable to collect comparative serum samples a few hr before performing thoracentesis.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to classify the type of effusion being produced and identify the cause of its accumulation.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and reproductive systems, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Discuss with the patient that the requesting HCP may request that a cough suppressant be given before the thoracentesis. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to needle insertion through the chest wall into the pleural space. Explain that any discomfort with the needle insertion will be minimized with local anesthetics and systemic analgesics. Explain that the local anesthetic injection may cause an initial stinging sensation. Meperidine (Demerol) or morphine may be given as a sedative. Inform the patient that the needle

insertion is performed under sterile conditions by a HCP specializing in this procedure. The procedure usually takes about 20 min to complete.

- ▶ Explain that an IV line will be inserted to allow infusion of IV fluids, antibiotics, anesthetics, and analgesics.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction. The requesting HCP may request that anticoagulants and aspirin be withheld. The number of days to withhold medication is dependent on the type of anticoagulant.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ▶ Have emergency equipment readily available. Keep resuscitation equipment on hand in the case of respiratory impairment or laryngospasm after the procedure.
- ▶ Avoid using morphine sulfate in those with asthma or other pulmonary disease. This drug can further exacerbate bronchospasms and respiratory impairment.
- ▶ Have the patient remove clothing and change into a gown for the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location.
- ▶ Record baseline vital signs and continue to monitor throughout the procedure. Protocols may vary from facility to facility.

- ◆ Establish an IV line to allow infusion of IV fluids, anesthetics, analgesics, or IV sedation.
- ◆ Assist the patient into a comfortable sitting or side-lying position.
- ◆ Prior to the administration of local anesthesia, shave and cleanse the site with an antiseptic solution and drape the area with sterile towels. The skin at the injection site is then anesthetized.
- ◆ The thoracentesis needle is inserted, and fluid is removed.
- ◆ The needle is withdrawn, and pressure is applied to the site with a vaseline gauze. A pressure dressing is applied over the vaseline gauze.
- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis).
- ◆ Place samples in properly labeled specimen container, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual medications, as directed by the HCP.
- ◆ Monitor vital signs every 15 min for the first hr, every 30 min for the next 2 hr, every hour for the next 4 hr, and every 4 hr for the next 24 hr. Take the patient's temperature every 4 hr for 24 hr. Monitor intake and output for 24 hr. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ◆ Observe the patient for signs of respiratory distress or skin color changes.
- ◆ Observe the thoracentesis site for bleeding, inflammation, or hematoma formation each time vital signs are taken and daily thereafter for several days.
- ◆ Observe the patient for hemoptysis, difficulty breathing, cough, air hunger, pain, or absent breathing sounds over the affected area. Report to HCP.
- ◆ Inform the patient that 1 hr or more of bed rest (lying on the unaffected side) is required after the procedure. Elevate the patient's head for comfort.

- ◆ Evaluate the patient for symptoms indicating the development of pneumothorax, such as dyspnea, tachypnea, anxiety, decreased breathing sounds, or restlessness. Prepare the patient for a chest x-ray, if ordered, to ensure that a pneumothorax has not occurred as a result of the procedure.
- ◆ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ◆ Administer antibiotics, as ordered, and instruct the patient in the importance of completing the entire course of antibiotic therapy even if no symptoms are present.
- ◆ Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services, if appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include antibodies anti-cyclic citrullinated peptide, ANA, biopsy lung, blood gases, CEA and cancer antigens, chest x-ray, complete blood count, WBC count and differential, CT thoracic, CRP, culture and smear mycobacteria, culture blood, culture fungal, culture viral, ECG, ESR, MRI chest, and RF.
- ◆ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Porphyryns, Urine

SYNONYM/ACRONYM: Coproporphyrin, porphobilinogen, urobilinogen, and other porphyryns.

SPECIMEN: Urine (10 mL) from a random or timed specimen collected in a clean, amber-colored plastic collection container with sodium carbonate as a preservative.

REFERENCE VALUE: (Method: Chromatography for uroporphyrins; spectrophotometry for d-aminolevulinic acid, urobilinogen, and porphobilinogen)

Test	Conventional Units	SI Units
Total porphyryns	Less than 320 mcg/24 hr	
Coproporphyrin		(Conventional Units × 1.53)
Tetracarboxyl-coproporphyrin		
Male	Less than 96 mcg/24 hr	Less than 147 nmol/24 hr
Female	Less than 60 mcg/24 hr	Less than 92 nmol/24 hr
Uroporphyrins		(Conventional Units × 1.43)
Pentacarboxyl-porphyrin		
Male	Less than 4 mcg/24 hr	Less than 6 nmol/24 hr
Female	Less than 3 mcg/24 hr	Less than 4 nmol/24 hr
Hexacarboxyl-porphyrin		(Conventional Units × 1.34)
Male	Less than 5 mcg/24 hr	Less than 7 nmol/24 hr
Female	Less than 3 mcg/24 hr	Less than 4 nmol/24 hr
Heptacarboxyl-porphyrin		(Conventional Units × 1.27)
Male	Less than 13 mcg/24 hr	Less than 17 nmol/24 hr
Female	Less than 9 mcg/24 hr	Less than 11 nmol/24 hr
Porphobilinogen		(Conventional Units × 4.42)
	Less than 2.0 mg/24 hr	Less than 8.8 micromol/24 hr
Urobilinogen		(Conventional Units × 1)
	0.5–4.0 Ehrlich units/24 hr	0.5–4.0 Ehrlich units/24 hr
δ-Aminolevulinic acid		(Conventional Units × 7.626)
	1.5–7.5 mg/24 hr	11.4–57.2 micromol/24 hr

DESCRIPTION: Porphyryns are produced during the synthesis of heme. If heme synthesis is

disturbed, these precursors accumulate and are excreted in the urine in excessive amounts.

Conditions producing increased levels of heme precursors are called *porphyrias*. The two main categories of genetically determined porphyrias are erythropoietic porphyrias, in which major abnormalities occur in red blood cell chemistry, and hepatic porphyrias, in which heme precursors are found in urine and feces. Erythropoietic and hepatic porphyrias are rare. Acquired porphyrias are characterized by greater accumulation of precursors in urine and feces than in red blood cells. Lead poisoning is the most common cause of acquired porphyrias. Porphyrins are reddish fluorescent compounds. Depending on the type of porphyrin present, the urine may be reddish, resembling port wine. Porphobilinogen is excreted as a colorless compound. A color change may occur in an acidic sample containing porphobilinogen if the sample is exposed to air for several hours.

INDICATIONS:

- Assist in the diagnosis of congenital or acquired porphyrias, characterized by abdominal pain, tachycardia, emesis, fever, leukocytosis, and neurologic abnormalities
- Detect suspected lead poisoning, as indicated by elevated porphyrins

RESULT:

Increased in:

- Acute hepatic porphyrias
- Congenital or acquired porphyrias
- Heavy metal, benzene, or carbon tetrachloride toxicity
- Variegated porphyrias

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase urine porphyrin levels include acriflavine, aminopyrine, ethoxazene, griseofulvin, hexachlorobenzene, oxytetracycline, and sulfonmethane.
- Numerous drugs are suspected as potential initiators of acute attacks, but drugs classified as unsafe for high-risk individuals include aminopyrine, aminogluthemide, antipyrine, barbiturates, *N*-butylscopolammoniumine bromide, carbamazepine, carbromal, chlorpropamide, danazol, dapsone, diclofenac, diphenylhydantoin, ergot preparations, ethchlorvynol, ethinamate, glutethimide, griseofulvin, *N*-isopropyl meprobamate, mephenytoin, meprobamate, methyprylon, novobiocin, phenylbutazone, primidone, pyrazolone preparations, succinimides, sulfonamide antibiotics, sulfonethylmethane, sulfonmethane, synthetic estrogens and progestins, tolazamide, tolbutamide, trimethadione, and valproic acid.
- Exposure of the specimen to light can falsely decrease values.
- Screening methods are not well standardized and can produce false-negative results.
- Failure to collect all urine and store specimen properly during the 24-hour test period will interfere with results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate porphyrias.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's hematopoietic system, symptoms and and results of previously performed laboratory tests, diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ Usually a 24-hour time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hour period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the

meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.

- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 minutes before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.

- ◆ Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that can affect test results.

General:

- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include δ -aminolevulinic acid, erythrocyte protoporphyrin, and lead.
- ◆ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Positron Emission Tomography, Brain

SYNONYM/ACRONYM: PET scan of the brain.

AREA OF APPLICATION: Brain.

CONTRAST: IV radioactive material (fluorodeoxyglucose [FDG]).

DESCRIPTION: Positron emission tomography (PET) combines the biochemical properties of nuclear medicine with the accuracy of computed tomography (CT). PET uses positron emissions from specific radionuclides (oxygen, nitrogen, carbon, and fluorine) to produce detailed functional images within the body. After the radionuclide becomes concentrated in the brain, PET images of blood flow or metabolic processes at the cellular level can be obtained. Fluorine-18, in the

form of fluorodeoxyglucose (FDG), is one of the more commonly used radionuclides. FDG is a glucose analogue, and because every cell uses glucose, the metabolic activity occurring in neurological conditions can be measured. There is little localization of FDG in normal tissue, allowing rapid detection of abnormal disease states. The brain uses oxygen and glucose almost exclusively to meet its energy needs, and therefore the brain's metabolism has been studied widely with PET.

The positron radiopharmaceuticals generally have short half-lives, ranging from a few seconds to a few hours, and therefore they must be produced in a cyclotron located near where the test is being done. The PET scanner translates the emissions from the radioactivity as the positron combines with the negative electrons from the tissues and forms gamma rays that can be detected by the scanner. This information is transmitted to the computer, which determines the location and its distribution and translates the emissions as color-coded images for viewing, quantitative measurements, activity changes in relation to time, and three-dimensional computer-aided analysis. Each radionuclide tracer is designed to measure a specific body process, such as glucose metabolism, blood flow, or brain tissue perfusion. The radionuclide can be administered IV or inhaled as a gas. PET has had the greatest clinical impact in patients with epilepsy, dementia, neurodegenerative diseases, inflammation, cerebrovascular disease (indirectly), and brain tumors.

The expense of the study and the limited availability of radiopharmaceuticals limit the use of PET, even though it is more sensitive than traditional nuclear scanning and single-photon emission computed tomography. Changes in reimbursement and the advent of mobile technology have increased the availability of this procedure in the community setting.

INDICATIONS:

- Detect Parkinson's disease and Huntington's disease, as evidenced by decreased metabolism
- Determine the effectiveness of therapy, as evidenced by biochemical

activity of normal and abnormal tissues

- Determine physiological changes in psychosis and schizophrenia
- Differentiate between tumor recurrence and radiation necrosis
- Evaluate Alzheimer's disease and differentiate it from other causes of dementia, as evidenced by decreased cerebral flow and metabolism
- Evaluate cranial tumors pre- and postoperatively and determine stage and appropriate treatment or procedure
- Identify cerebrovascular accident or aneurysm, as evidenced by decreased blood flow and oxygen use
- Identify focal seizures, as evidenced by decreased metabolism between seizures

RESULT:

Normal findings in:

- Normal patterns of tissue metabolism, blood flow, and radionuclide distribution

Abnormal findings in:

- Alzheimer's disease
- Aneurysm
- Cerebral metastases
- Cerebrovascular accident
- Creutzfeldt-Jakob disease
- Dementia
- Head trauma
- Huntington's disease
- Migraine
- Parkinson's disease
- Schizophrenia
- Seizure disorders
- Tumors

CRITICAL VALUES:

- Aneurysm
- CVA
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Drugs that alter glucose metabolism, such as tranquilizers or insulin, because hypoglycemia can alter PET results
- The use of alcohol, tobacco, or caffeine-containing drinks at least 24 hr before the study, because the effects of these substances would make it difficult to evaluate the patient's true physiological state (e.g., alcohol is a vasoconstrictor and would decrease blood flow to the target organ)
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Improper injection of the radionuclide that allows the tracer to seep deep into the muscle tissue produces erroneous hot spots.
- False-positive findings may occur as a result of normal gastrointestinal tract uptake and uptake in areas of infection or inflammation.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.

- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses blood flow to the brain and brain tissue metabolism.
- ▶ Obtain a history of the patient's complaints including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ▶ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the medications the patient is taking, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that radioactive material poses minimal radioactive hazard because of its short half-life and rarely produces side effects. Inform the patient that the procedure is performed in a special department, usually in a radiology suite, by a HCP specializing in this

procedure, with support staff, and takes approximately 60 to 120 min.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Sometimes FDG examinations are done after blood has been drawn to determine circulating blood glucose levels. If blood glucose levels are high, insulin may be given.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure.
- ▶ Instruct the patient to restrict food for 4 hr; restrict alcohol, nicotine, or caffeine-containing drinks for 24 hr; and withhold medications for 24 hr before the test. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions and pretesting preparations.
- ▶ Ensure the patient has removed all jewelry and external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Place the patient in the supine position on an exam table.
- ▶ The radionuclide is injected, and imaging is started after a 30-min delay. If

comparative studies are indicated, additional injections may be needed.

- ▶ The patient may be asked to perform different cognitive activities (e.g., reading) to measure changes in brain activity during reasoning or remembering.
- ▶ The patient may be blindfolded or asked to use earplugs to decrease auditory and visual stimuli.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume pretest diet, fluids, medications, or activity.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Educate the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ Instruct the patient to flush the toilet immediately after each voiding, and to meticulously wash hands with soap and water for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated, about 3 days. Instruct her to express the milk and discard it during the 3-day period to prevent cessation of milk production.

- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing,

treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include Alzheimer disease markers, CT brain, EEG, MRI brain, and US arterial Doppler of the carotids.
- ▶ Refer to the Musculoskeletal System table in the back of the book for related tests by body system.

Positron Emission Tomography, Heart

SYNONYM/ACRONYM: PET scan of the heart.

AREA OF APPLICATION: Heart, chest/thorax, vascular system.

CONTRAST: IV radioactive material (fluorodeoxyglucose [FDG]).

DESCRIPTION: Positron emission tomography (PET) combines the biochemical properties of nuclear medicine with the accuracy of computed tomography (CT). PET uses positron emissions from specific radionuclides (oxygen, nitrogen, carbon, and fluorine) to produce detailed functional images within the body. After the radionuclide becomes concentrated in the heart, PET images of blood flow or metabolic processes at the cellular level can be obtained. Fluorine-18, in the form of fluorodeoxyglucose (FDG), is one of the more commonly used radionuclides. FDG is a glucose analogue, and because every cell

uses glucose, the metabolic activity occurring in heart conditions such as myocardial viability can be measured. There is little localization of FDG in normal tissue, allowing rapid detection of abnormal disease states.

The positron radiopharmaceuticals generally have short half-lives, ranging from a few seconds to a few hours, and therefore they must be produced in a cyclotron located near where the test is being done. The PET scanner translates the emissions from the radioactivity as the positron combines with the negative electrons from the tissues and forms gamma rays that can be detected by the scanner. This information is transmitted to

the computer, which determines the location and its distribution and translates the emissions as color-coded images for viewing, quantitative measurements, activity changes in relation to time, and three-dimensional computer-aided analysis. Each radionuclide tracer is designed to measure a specific body process, such as glucose metabolism, blood flow, or tissue perfusion. The radionuclide can be administered IV or inhaled as a gas.

The expense of the study and the limited availability of radiopharmaceuticals limit the use of PET, even though it is more sensitive than traditional nuclear scanning and single-photon emission computed tomography. Changes in reimbursement and the advent of mobile technology have increased the availability of this procedure in the community setting.

INDICATIONS:

- Assess tissue permeability
- Determine the effects of therapeutic drugs on malfunctioning or diseased tissue
- Determine localization of areas of heart metabolism
- Determine the presence of coronary artery disease (CAD), as evidenced by metabolic state during ischemia and after angina
- Determine the size of heart infarcts
- Identify cerebrovascular accident or aneurysm, as evidenced by decreasing blood flow and oxygen use

RESULT:

Normal findings in:

- Normal patterns of tissue metabolism, blood flow, and radionuclide distribution

Abnormal findings in:

- Chronic obstructive pulmonary disease

- Decreased blood flow and decreased glucose concentration, indicating necrotic, scarred tissue
- Enlarged left ventricle
- Heart chamber disorder
- Myocardial infarction, indicating increased radionuclide uptake in the myocardium
- Pulmonary edema
- Reduced blood flow but increased glucose concentration, indicating ischemia

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Drugs that alter glucose metabolism, such as tranquilizers or insulin, because hypoglycemia can alter PET results
- The use of alcohol, tobacco, or caffeine-containing drinks at least 24 hr before the study, because the effects of these substances would make it difficult to evaluate the patient's true physiological state (e.g., alcohol is a vasoconstrictor and would decrease blood flow to the target organ)
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary restrictions before the procedure may

cause the procedure to be canceled or repeated.

- Improper injection of the radionuclide that allows the tracer to seep deep into the muscle tissue produces erroneous hot spots.
- False-positive findings may occur as a result of normal gastrointestinal tract uptake and uptake in areas of infection or inflammation.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses blood flow to the heart.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the medications the patient is taking, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, or there may be moments of discomfort. Reassure the patient that radioactive material poses minimal radioactive hazard because of its short half-life and rarely produces side effects. Inform the patient that the procedure is performed in a special department, usually in a radiology suite, by a HCP specializing in this procedure, with support staff, and takes approximately 60 to 120 min.

Sensitivity to social and cultural issues, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ Sometimes FDG examinations are done after blood has been drawn to determine circulating blood glucose levels. If blood glucose levels are high, insulin may be given.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure.
- ▶ Instruct the patient to restrict food for 4 hr; restrict alcohol, nicotine, or caffeine-containing drinks for 24 hr; and withhold medications for 24 hr before the test. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions and pretesting preparations.
- ▶ Ensure the patient has removed all jewelry and external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.

- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Place the patient in the supine position on an exam table.
- ▶ The radionuclide is injected and imaging is done at periodic intervals, with continuous scanning done for 1 hr. If comparative studies are indicated, additional injections may be needed.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume pretest diet, fluids, medications, and activity.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Instruct the patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Educate the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ Instruct the patient to flush the toilet immediately after each voiding, and to meticulously wash hands with soap and water for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated, about 3 days. Instruct her to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and CAD.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests for cardiac indications include anion gap, antiarrhythmic drugs, apolipoprotein A and B, arterial/alveolar oxygen ratio, AST, ANP, α_1 -AT, biopsy lung, blood gases, blood pool imaging, BNP, bronchoscopy, calcium, ionized calcium, carboxyhemoglobin, chest x-ray, chloride sweat, cholesterol (total, HDL, and LDL), CRP, complete blood count, CT cardiac scoring, CT thoracic, CK and isoenzymes, culture and smear for mycobacteria, culture bacterial sputum, culture viral, cytology sputum,

echocardiography, echocardiography transesophageal, ECG, electrolytes, exercise stress test, glucose, glycated hemoglobin, gram stain, Hgb, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI chest, MI infarct scan, IgE, lactic acid, lung perfusion scan, lung ventilation scan, myocardial perfusion heart scan, myoglobin, osmolality, pericardial fluid analysis, phosphorus, plethysmography, pleural fluid analysis, PET heart, PFT, potassium, pulse oximetry, TB skin test, and triglycerides. Related tests for pulmonary indications include α_1 -AT, anion gap, arterial/alveolar oxygen

ratio, biopsy lung, bronchoscopy, carboxyhemoglobin, chest x-ray, chloride sweat, complete blood count, complete blood count, hemoglobin, complete blood count, WBC count and differential, culture and smear for mycobacteria, culture bacterial sputum, culture viral, cytology sputum, electrolytes, gram stain, IgE, lactic acid, lung perfusion scan, lung ventilation scan, osmolality, phosphorus, plethysmography, pleural fluid analysis, and pulse oximetry.

Refer to the Cardiovascular and Respiratory System tables in the back of the book for related tests by body system.

Positron Emission Tomography, Pelvis

SYNONYM/ACRONYM: PET scan of the pelvis.

AREA OF APPLICATION: Pelvis.

CONTRAST: IV radioactive material (fluorodeoxyglucose [FDG]).

DESCRIPTION: Positron emission tomography (PET) combines the biochemical properties of nuclear medicine with the accuracy of computed tomography (CT). PET uses positron emissions from specific radionuclides (oxygen, nitrogen, carbon, and fluorine) to produce detailed functional images within the body. After the radionuclide becomes concentrated in the pelvis, PET images of blood flow or metabolic processes at the cellular level can be obtained. Colorectal tumor detection, tumor staging, evaluation of the effects of therapy, detection of recurrent disease, and detection of metastases are the main reasons to do a pelvic PET scan. Fluorine-18, in the form of

fluorodeoxyglucose (FDG), is one of the more commonly used radionuclides. FDG is a glucose analogue, and because every cell uses glucose, the metabolic activity occurring in pelvic conditions such as colorectal cancer can be measured. There is little localization of FDG in normal tissue, allowing rapid detection of abnormal disease states.

The positron radiopharmaceuticals generally have short half-lives, ranging from a few seconds to a few hours, and therefore they must be produced in a cyclotron located near where the test is being done. The PET scanner translates the emissions from the radioactivity as the positron combines with the negative electrons from the

tissues and forms gamma rays that can be detected by the scanner. This information is transmitted to the computer, which determines the location and its distribution and translates the emissions as color-coded images for viewing, quantitative measurements, activity changes in relation to time, and three-dimensional computer-aided analysis. Each radionuclide tracer is designed to measure a specific body process, such as glucose metabolism, blood flow, or tissue perfusion.

The expense of the study and the limited availability of radiopharmaceuticals limit the use of PET, even though it is more sensitive than traditional nuclear scanning and single-photon emission computed tomography. Changes in reimbursement and the advent of mobile technology have increased the availability of this procedure in the community setting.

INDICATIONS:

- Determine the effects of therapy
- Determine the presence of colorectal cancer
- Determine the presence of metastases of a cancerous tumor
- Determine the recurrence of tumor or cancer
- Identify the site for biopsy

RESULT:

Normal findings in:

- Normal patterns of tissue metabolism, blood flow, and radionuclide distribution
- No focal uptake of radionuclide

Abnormal findings in:

- Focal uptake of the radionuclide in pelvis
- Focal uptake in abnormal lymph nodes

- Focal uptake in tumor
- Focal uptake in metastases

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Drugs that alter glucose metabolism, such as tranquilizers or insulin, because hypoglycemia can alter PET results
- The use of alcohol, tobacco, or caffeine-containing drinks at least 24 hr before the study, because the effects of these substances would make it difficult to evaluate the patient's true physiological state (e.g., alcohol is a vasoconstrictor and would decrease blood flow to the target organ)
- Metallic objects within the examination field (e.g., jewelry, body rings), which may inhibit organ visualization and can produce unclear images

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Improper injection of the radionuclide that allows the tracer to seep deep into the muscle tissue produces erroneous hot spots.
- False-positive findings may occur as a result of normal gastrointestinal (GI) tract uptake and uptake in areas of infection or inflammation.

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the pelvis and its contents for abnormal organ function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ▶ Obtain a history of the patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the medications the patient is taking, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort. Reassure the patient that radioactive material poses minimal radioactive hazard because of its short half-life and rarely

produces side effects. Inform the patient that the procedure is performed in a special department, usually in a radiology suite, by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Sometimes FDG examinations are done after blood has been drawn to determine circulating blood glucose levels. If blood glucose levels are high, insulin may be given.
- ▶ Instruct the patient to remove jewelry and other metallic objects in the area to be examined.
- ▶ Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure.
- ▶ Instruct the patient to restrict food for 4 hr; restrict alcohol, nicotine, or caffeine-containing drinks for 24 hr; and withhold medications for 24 hr before the test. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions and pretesting preparations.
- ▶ Ensure the patient has removed all jewelry and external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.

- ◆ Place the patient in the supine position on an exam table.
- ◆ The radionuclide is injected, and imaging is started after a 45-min delay. Continuous scanning may be done for 1 hr. If comparative studies are indicated, additional injections of radionuclide may be needed.
- ◆ If required, the bladder may need to be lavaged via a urinary catheter with 2 L of 0.9% saline solution to remove concentrated radionuclide.
- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume pretest diet, fluids, medications, and activity.
- ◆ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ◆ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ◆ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ◆ Instruct the patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Tell the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ◆ Instruct the patient to flush the toilet immediately after each voiding, and to meticulously wash hands with soap and water for 24 hr after the procedure.

- ◆ Tell all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ◆ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated, about 3 days. Instruct her to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ◆ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ◆ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include barium enema, biopsy intestinal, capsule endoscopy, cancer antigens, CT abdomen, fecal analysis, KUB, CT colonoscopy, MRI abdomen, and proctosigmoidoscopy.
- ◆ Refer to the Gastrointestinal System table in the back of the book for related tests by body system.

Potassium, Blood

SYNONYM/ACRONYM: Serum K⁺.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Ion-selective electrode)

Serum	Conventional Units	SI Units (Conventional Units × 1)
Newborn	3.7–5.9 mEq/L	3.7–5.9 mmol/L
Infant	4.1–5.3 mEq/L	4.1–5.3 mmol/L
Child	3.4–4.7 mEq/L	3.4–4.7 mmol/L
Adult	3.5–5.0 mEq/L	3.5–5.0 mmol/L

Note: Serum values are 0.1 mmol/L higher than plasma values, and reference ranges should be adjusted accordingly. It is important that serial measurements be collected using the same type of collection container to reduce variability of results from collection to collection.

DESCRIPTION: Electrolytes dissociate into electrically charged ions when dissolved. Cations, including potassium, carry a positive charge. Body fluids contain approximately equal numbers of anions and cations, although the nature of the ions and their mobility differs between the intracellular and extracellular compartments. Both types of ions affect the electrical and osmolar functions of the body. Electrolyte quantities and the balance among them are controlled by oxygen and carbon dioxide exchange in the lungs; absorption, secretion, and excretion of many substances by the kidneys; and secretion of regulatory hormones by the endocrine glands. Potassium is the most abundant intracellular cation. It is essential for the transmission of electrical impulses in cardiac and skeletal muscle. It also functions in enzyme reactions that transform glucose into energy and amino acids into proteins. Potassium helps main-

tain acid-base equilibrium, and it has a significant and inverse relationship to pH: A decrease in pH of 0.1 increases the potassium level by 0.6 mEq/L.

Abnormal potassium levels can be caused by a number of contributing factors, which can be categorized as follows:

Altered renal excretion: Normally, 80% to 90% of the body's potassium is filtered out through the kidneys each day (the remainder is excreted in sweat and stool); renal disease can result in abnormally high potassium levels.

Altered dietary intake: A severe potassium deficiency can be caused by an inadequate intake of dietary potassium.

Altered cellular metabolism: Damaged red blood cells (RBCs) release potassium into the circulating fluid, resulting in increased potassium levels.

INDICATIONS:

- Assess a known or suspected disorder associated with renal disease, glucose metabolism, trauma, or burns

- Assist in the evaluation of electrolyte imbalances; this test is especially indicated in elderly patients, patients receiving hyperalimentation supplements, patients on hemodialysis, and patients with hypertension
- Evaluate cardiac arrhythmia to determine whether altered potassium levels are contributing to the problem, especially during digitalis therapy, which leads to ventricular irritability
- Evaluate the effects of drug therapy, especially diuretics
- Evaluate the response to treatment for abnormal potassium levels
- Monitor known or suspected acidosis, because potassium moves from RBCs into the extracellular fluid in acidotic states
- Routine screen of electrolytes in acute and chronic illness

RESULT:

Increased in:

- Acidosis (*Intracellular potassium ions are expelled in exchange for hydrogen ions in order to achieve electrical neutrality*)
- Acute renal failure (*Potassium excretion is diminished and it accumulates in the blood*)
- Addison's disease (*Due to lack of aldosterone, potassium excretion is diminished and it accumulates in the blood*)
- Asthma (*Related to chronic inflammation and damage to lung tissue*)
- Burns (*Related to tissue damage and release by damaged cells*)
- Chronic interstitial nephritis (*Potassium excretion is diminished and it accumulates in the blood*)
- Dehydration (*Hemoconcentration*)
- Dialysis (*Dialysis treatments simulate kidney function but potassium builds up between treatments*)
- Diet (*Related to excessive intake of salt substitutes or of potassium salts in medications*)
- Exercise (*Related to tissue damage and release by damaged cells*)
- Hemolysis (massive) (*Potassium is the major intracellular cation*)
- Hyperventilation (*Response to respiratory alkalosis is increased blood levels of potassium in order to achieve electrical neutrality*)
- Hypoaldosteronism (*Due to lack of aldosterone, potassium excretion is diminished and it accumulates in the blood*)
- Insulin deficiency (*Insulin deficiency results in movement of potassium from the cell into the extracellular fluid*)
- Ketoacidosis (*Insulin deficiency results in movement of potassium from the cell into the extracellular fluid*)
- Leukocytosis
- Muscle necrosis (*Related to tissue damage and release by damaged cells*)
- Near drowning
- Pregnancy
- Prolonged periods of standing
- Tissue trauma (*Release by damaged cells*)
- Transfusion of old banked blood (*Aged cells hemolyze and release intracellular potassium*)
- Tubular unresponsiveness to aldosterone
- Uremia

Decreased in:

- Alcoholism (*Related to insufficient dietary intake*)
- Alkalosis (*Potassium uptake by cells is increased in response to release of hydrogen ions from cells*)
- Anorexia nervosa (*Related to significant changes in renal function that result in hypokalemia*)
- Bradycardia (*Hypokalemia can cause bradycardia*)

- Chronic, excessive licorice ingestion (from licorice root)
- Congestive heart failure (**Related to fluid retention and hemodilution**)
- Crohn's disease (**Insufficient intestinal absorption**)
- Cushing's syndrome (**Aldosterone facilitates the excretion of potassium by the kidneys**)
- Diet deficient in meat and vegetables (**Insufficient dietary intake**)
- Excess insulin (**Insulin causes glucose and potassium to move into cells**)
- Familial periodic paralysis (**Related to fluid retention**)
- Gastrointestinal (GI) loss due to vomiting, diarrhea, nasogastric suction, or intestinal fistula
- Hyperaldosteronism (**Aldosterone facilitates the excretion of potassium by the kidneys**)
- Hypertension (**Medications used to treat hypertension may result in loss of potassium; hypertension is often related to diabetes and renal disease which affect cellular retention and renal excretion of potassium respectively**)
- Hypomagnesemia (**Magnesium levels tend to parallel potassium levels**)
- IV therapy with inadequate potassium supplementation
- Laxative abuse (**Medications cause potassium wasting**)
- Malabsorption (**Insufficient intestinal absorption**)
- Pica (eating substances of no nutritional value, e.g., clay)
- Renal tubular acidosis (**Condition results in excessive loss of potassium**)
- Sweating (**Increased loss**)
- Theophylline administration, excessive (**Theophylline drives potassium into cells, reducing circulating levels**)

- Thyrotoxicosis (**Related to changes in renal function**)

CRITICAL VALUES:

- Less than 2.5 mmol/L
- Greater than 6.5 mmol/L
- Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms, especially symptoms of fluid imbalance.
- Symptoms of hyperkalemia include irritability, diarrhea, cramps, oliguria, difficulty speaking, and cardiac arrhythmias (peaked T waves and ventricular fibrillation). Continuous cardiac monitoring is indicated. Administration of sodium bicarbonate or calcium chloride may be requested. If the patient is receiving an IV supplement, verify that the patient is voiding.
- Symptoms of hypokalemia include malaise, thirst, polyuria, anorexia, weak pulse, low blood pressure, vomiting, decreased reflexes, and electrocardiographic changes (depressed T waves and ventricular ectopy). Replacement therapy is indicated.

INTERFERING FACTORS:

- Drugs that can cause an increase in potassium levels include dexamethasone, enalapril, mannitol, methicillin, metoprolol, NSAIDs, some drugs with potassium salts, propranolol, spironolactone, and succinylcholine.
- Drugs that can cause a decrease in potassium levels include acetazolamide, acetylsalicylic acid, alanine, albuterol, aldosterone, ammonium chloride, amphotericin B, bicarbonate, bisacodyl, captopril, carbenicillin, cathartics, cisplatin, clorexolone, desoxycorticosterone, dexamethasone, digoxin, diuretics, enalapril, furosemide, hydrocortisone, hydroflumethiazide, laxatives, moxalactam (common

when coadministered with amikacin), large doses of any IV penicillin, phenolphthalein (with chronic laxative abuse), phosphates, IV theophylline, thiazides, and trimterene. A number of these medications initially increase the serum potassium level, but they also have a diuretic effect, which promotes potassium loss in the urine except in cases of renal insufficiency.

- Leukocytosis, as seen in leukemia, causes elevated potassium levels.
- False elevations can occur with vigorous pumping of the hand during venipuncture. Hemolysis of the sample and high platelet counts also increase potassium levels, as follows: (1) Because potassium is an intracellular ion and concentrations are approximately 150 times extracellular concentrations, even a slight amount of hemolysis can cause a significant increase in levels. (2) Platelets release potassium during the clotting process, and therefore serum samples collected from patients with elevated platelet counts may produce spuriously high potassium levels. Plasma would be the specimen of choice in patients known to have elevated platelet counts.
- False increases are seen in unprocessed samples left at room temperature because a significant amount of potassium leaks out of the cells within a few hr. Plasma or serum should be separated from cells within 4 hr of collection.
- Storage of unprocessed blood causes potassium levels to increase because a significant amount of potassium leaks out of the cells within a few hr. Plasma or serum should be separated from cells within 4 hr of collection.
- Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, falsely

decreasing the result. There is also the potential of contaminating the sample with the substance of interest, if it is present in the IV solution, falsely increasing the result.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to assess electrolyte balance.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex. Especially note complaints of weakness and confusion.
- ◆ Obtain a history of the patient's cardiovascular, endocrine, GI, genitourinary, immune, and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement. Instruct patient not to clench and unclench the fist immediately before or during specimen collection.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label

the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** There are no recommended dietary allowances established for potassium, but the estimated minimum intake for adults is 200 mEq/d. Potassium is present in all plant and animal cells, making dietary replacement simple to achieve in the potassium-deficient patient.
- ▶ Observe the patient for signs and symptoms of fluid volume excess related to excess potassium intake, fluid volume deficit related to active loss, or risk of injury related to an alteration in body chemistry. Symptoms include dehydration, diarrhea, vomiting, or prolonged anorexia. Instruct the patient in electrolyte replacement therapy and changes in dietary intake that affect electrolyte levels.
- ▶ Increased potassium levels may be associated with dehydration. Evaluate the patient for signs and symptoms of dehydration. Dehydration is a significant and common finding in geriatric patients and other patients in whom renal function has deteriorated.

- ▶ Patients receiving digoxin or diuretics should have potassium levels monitored carefully because cardiac arrhythmias can occur.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, aldosterone, anion gap, antiarrhythmic drugs, alveolar/arterial gradient, ANP, BNP, blood gases, BUN, calcium, carbon dioxide, chloride, complement, complete blood count, hematocrit, complete blood count, hemoglobin, complete blood count, WBC count and differential, Coomb's antiglobulin (direct and indirect), cortisol, CK and isoenzymes, creatinine, DHEAS, echocardiography, echocardiography transesophageal, fecal fat, glucose, G6PD, Ham's test, haptoglobin, hemosiderin, insulin, ketones, lactic acid, lung perfusion scan, magnesium, osmolality, osmotic fragility, plethysmography, urine potassium, PFT, PK, renin, sickle cell screen, and sodium.
- ▶ Refer to the Cardiovascular, Endocrine, Gastrointestinal, Genitourinary, Immune, and Respiratory System tables at the back of the book for related tests by body system.

Potassium, Urine

SYNONYM/ACRONYM: Urine K⁺.

SPECIMEN: Urine (5 mL) from an unpreserved random or timed specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Ion-selective electrode).

Age	Conventional Units	SI Units (Conventional Units × 1)
6–10 yr		
Male	17–54 mEq/24 hr	17–54 mmol/24 hr
Female	8–37 mEq/24 hr	8–37 mmol/24 hr
10–14 yr		
Male	22–57 mEq/24 hr	22–57 mmol/24 hr
Female	18–58 mEq/24 hr	18–58 mmol/24 hr
Adult	26–123 mEq/24 hr	26–123 mmol/24 hr

Note: Reference values depend on potassium intake and diurnal variation. Excretion is significantly higher at night.

DESCRIPTION: Electrolytes dissociate into electrically charged ions when dissolved. Cations, including potassium, carry a positive charge. Body fluids contain approximately equal numbers of anions and cations, although the nature of the ions and their mobility differs between the intracellular and extracellular compartments. Both types of ions affect the electrical and osmolar functions of the body. Electrolyte quantities and the balance among them are controlled by oxygen and carbon dioxide exchange in the lungs; absorption, secretion, and excretion of many substances by the kidneys; and secretion of regulatory hormones by the endocrine glands. Potassium is the most abundant intracellular cation. It is essential for the transmission of electrical impulses in cardiac and skeletal muscle. It also functions in enzyme reactions that transform glucose into energy and amino acids into proteins. Potassium helps maintain acid-base equilibrium, and it has a significant and inverse relationship to pH: A decrease in pH of 0.1 increases the potassium level by 0.6 mEq/L.

Abnormal potassium levels can be caused by a number of contributing factors, which can be categorized as follows:

Altered renal excretion: Normally, 80% to 90% of the body's potassium is filtered out through the kidneys each day (the remainder is excreted in sweat and stool); renal disease can result in abnormally high potassium levels.

Altered dietary intake: A severe potassium deficiency can be caused by an inadequate intake of dietary potassium.

Altered cellular metabolism: Damaged red blood cells (RBCs) release potassium into the circulating fluid, resulting in increased potassium levels.

Regulating electrolyte balance is one of the major functions of the kidneys. In normally functioning kidneys, urine potassium levels increase when serum levels are high and decrease when serum levels are low to maintain homeostasis. The kidneys respond to alkalosis by excreting potassium to retain hydrogen ions and increase acidity. In acidosis, the body excretes hydrogen ions and retains potassium. Analyzing these urinary levels can provide important clues to the functioning of the kidneys and other major organs. Urine potassium tests usually involve timed urine collections over a 12- or 24-hr period. Measurement of random specimens also may be requested.

INDICATIONS:

- Determine the potential cause of renal calculi
- Evaluate known or suspected endocrine disorder
- Evaluate known or suspected renal disease
- Evaluate malabsorption disorders

RESULT:**Increased in:**

- Albright-type renal disease (*Related to excessive production of cortisol*)
- Cushing's syndrome (*Excessive corticosteroids, especially aldosterone levels will increase urinary excretion of potassium*)
- Diabetic ketoacidosis (*Deficiency of insulin forces potassium into the extracellular fluid; excess potassium is excreted in the urine*)
- Diuretic therapy (*Related to potassium wasting effects of the medications*)
- Hyperaldosteronism (*Excessive aldosterone levels will increase urinary excretion of potassium*)
- Starvation (onset) (*Cells involved in providing energy through tissue breakdown release potassium into circulation*)
- Vomiting (*Elevated urine potassium is a hallmark of bulimia*)

Decreased in:

- Addison's disease (*Reduced aldosterone levels will diminish excretion of potassium by the kidneys*)
- Potassium deficiency (chronic)
- Renal failure with decreased urine flow

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs and substances that can cause an increase in urine potassium levels include acetazolamide, acetylsalicylic acid, ammonium

chloride, bendroflumethiazide, carbamazepine, chlorthalidone, citrates, clopamide, corticosteroids, cortisone, desoxycorticosterone, dexamethasone, diuretics, dopamine, ethacrynic acid, glycyrrhiza, intra-amniotic saline, mefruside, niacinamide, some oral contraceptives, thiazides, triflucin, and viomycin.

- Drugs that can cause a decrease in urine potassium levels include alinine, amiloride, anesthetic agents, cyclosporine, felodipine, levarterenol, and ramipril.
- A dietary deficiency or excess of potassium can lead to spurious results.
- Diuretic therapy with excessive loss of electrolytes into the urine may falsely elevate results.
- All urine voided for the timed collection period must be included in the collection or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.
- Potassium levels are subject to diurnal variation (output being highest at night), which is why 24-hr collections are recommended.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate electrolyte balance, acid-base balance, and hypokalemia.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine, gastrointestinal, and genitourinary systems, symptoms, and

results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the

meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.

- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.

- ◆ Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that can affect test results.

General:

- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

- ◆ **Nutritional considerations:** There are no recommended dietary allowances established for potassium, but the estimated minimum intake for adults is 200 mEq/d. Potassium is present in all plant and animal cells, making dietary replacement simple to achieve in the potassium-deficient patient.

- ◆ Observe the patient for signs and symptoms of fluid volume excess related to excess potassium intake, fluid volume deficit related to active loss, or risk of injury related to an alteration in body chemistry. Symptoms include dehydration, diarrhea, vomiting, or prolonged anorexia. Instruct the patient in electrolyte replacement therapy and changes in dietary intake that affect electrolyte levels.

- ◆ Increased potassium levels may be associated with dehydration. Evaluate the patient for signs and symptoms of dehydration. Dehydration is a significant and common finding in geriatric patients and other patients in whom renal function has deteriorated.

- ◆ Patients receiving digoxin or diuretics should have potassium levels monitored carefully because cardiac arrhythmias can occur.
- ◆ Increased urine potassium levels may be associated with the formation of kidney stones. Educate the patient, if appropriate, on the importance of drinking a sufficient amount of water when kidney stones are suspected.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ACTH, aldosterone, anion gap, BUN, calcium, calculus kidney stone panel, carbon dioxide, chloride, cortisol, creatinine, DHEAS, glucose, insulin, ketones, lactic acid, magnesium, osmolality, phosphorus, potassium, renin, sodium, and UA.
- ◆ Refer to the Endocrine, Gastrointestinal, and Genitourinary System tables at the back of the book for related tests by body system.

P

Prealbumin

SYNONYM/ACRONYM: Transthyretin.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Nephelometry)

Age	Conventional Units	SI Units (Conventional Units × 10)
Newborn–1 mo	7.0–39.0 mg/dL	70–390 mg/L
1–6 mo	8.3–34.0 mg/dL	83–340 mg/L
6 mo–4 yr	2.0–36.0 mg/dL	20–360 mg/L
5–6 yr	12.0–30.0 mg/dL	120–300 mg/L
6 yr–adult	12.0–42.0 mg/dL	120–420 mg/L

DESCRIPTION: Prealbumin is a protein primarily produced by the liver. It is the major transport protein for triiodothyronine and thyroxine. It is also important in the metabolism of retinol-binding protein, which is needed for transporting vitamin A (retinol). Prealbumin has a short biological half-life of 2 days. This makes it a good indicator of protein status and an excellent marker for malnutrition. Prealbumin is often measured simultaneously with transferrin and albumin.

INDICATIONS:

Evaluate nutritional status

RESULT:

Increased in:

- Alcoholism (*Related to leakage of prealbumin from damaged hepatocytes and/or poor nutrition*)
- Chronic renal failure (*Rapid turnover of prealbumin reflects a perceived elevation in the presence of overall loss of other proteins that take longer to produce*)
- Patients receiving steroids (*These drugs stimulate production of prealbumin*)

Decreased in:

- Acute-phase inflammatory response (*Prealbumin is a negative acute phase reactant protein; levels decrease in the presence of inflammation*)

- Diseases of the liver (*Related to decreased ability of the damaged liver to synthesize protein*)
- Hepatic damage (*Related to decreased ability of the damaged liver to synthesize protein*)
- Malnutrition (*Synthesis is decreased due to lack of proper diet*)
- Tissue necrosis (*Prealbumin is a negative acute phase reactant protein; levels decrease in the presence of inflammation*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase prealbumin levels include anabolic steroids, anticonvulsants, danazol, oral contraceptives, prednisolone, prednisone, and propranolol.
- Drugs that may decrease prealbumin levels include amiodarone and diethylstilbestrol.
- Fasting 4 hr before specimen collection is highly recommended. Reference ranges are often based on fasting populations to provide some level of standardization for comparison. The presence of lipids in the blood may also interfere with the test method; fasting eliminates this potential source of error, especially if the patient has elevated lipid levels.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to evaluate nutritional status and assess liver function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine, gastrointestinal, and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to fast for 4 hr before specimen collection.
- ▶ There are no fluid or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 4 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop

bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ **Nutritional considerations:** Nutritional therapy may be indicated for patients with decreased prealbumin levels. Educate the patient, as appropriate, that good dietary sources of complete protein (containing all eight essential amino acids) include meat, fish, eggs, and dairy products; and that good sources of incomplete protein (lacking one or more of the eight essential amino acids) include grains, nuts, legumes, vegetables, and seeds.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include albumin, chloride, ferritin, iron/TIBC, potassium, protein, sodium, T4, T3, transferrin, and vitamin A.
- ▶ Refer to the Endocrine, Gastrointestinal, and Hepatobiliary System tables at the back of the book for related tests by body system.

Proctosigmoidoscopy

SYNONYM/ACRONYM: Anoscopy (anal canal), proctoscopy (rectum), sigmoidoscopy (sigmoid colon), flexible fiberoptic sigmoidoscopy, flexible proctosigmoidoscopy.

AREA OF APPLICATION: Anus, rectum, colon.

CONTRAST: Air.

DESCRIPTION: Proctosigmoidoscopy allows direct visualization of the mucosa of the anal canal (anoscopy), rectum (proctoscopy), and distal sigmoid colon (sigmoidoscopy). The procedure can be performed using a rigid or flexible fiberoptic endoscope, but the flexible instrument is generally preferred. The endoscope is a multichannel device allowing visualization of the mucosal lining of the colon, instillation of air, removal of fluid and foreign objects, obtaining of tissue biopsy specimens, and use of a laser for the destruction of tissue and control of bleeding. The endoscope is advanced approximately 60 cm into the colon. This procedure is commonly used in patients with lower abdominal and perineal pain; changes in bowel habits; rectal prolapse during defecation; or passage of blood, mucus, or pus in the stool. Proctosigmoidoscopy can also be a therapeutic procedure, allowing removal of polyps or hemorrhoids or reduction of a volvulus. Biopsy specimens of suspicious sites may be obtained during the procedure. This procedure is recommended for patients who are more than 50 y.o. as part of a routine screening for colorectal cancer.

INDICATIONS:

- Confirm the diagnosis of diverticular disease
- Confirm the diagnosis of Hirschsprung's disease and colitis in children
- Determine the cause of pain and rectal prolapse during defecation
- Determine the cause of rectal itching, pain, or burning
- Evaluate the cause of blood, pus, or mucus in the stool
- Evaluate postoperative anastomosis of the colon
- Examine the distal colon before barium enema (BE) x-ray to obtain improved visualization of the area, and after a BE when x-ray findings are inconclusive
- Reduce volvulus of the sigmoid colon
- Remove hemorrhoids by laser therapy
- Screen for and excise polyps
- Screen for colon cancer

RESULT:

Normal findings in:

- Normal mucosa of the anal canal, rectum, and sigmoid colon

Abnormal findings in:

- Anal fissure or fistula
- Anorectal abscess
- Benign lesions
- Bleeding sites
- Bowel infection or inflammation
- Crohn's disease
- Diverticula
- Hypertrophic anal papillae

- Internal and external hemorrhoids
- Polyps
- Rectal prolapse
- Tumors
- Ulcerative colitis
- Vascular abnormalities

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with bleeding disorders, especially disorders associated with uremia and cytotoxic chemotherapy
- Patients with cardiac conditions or arrhythmias
- Patients with bowel perforation, acute peritonitis, ischemic bowel necrosis, toxic megacolon, diverticulitis, recent bowel surgery, advanced pregnancy, severe cardiac or pulmonary disease, recent myocardial infarction, known or suspected pulmonary embolus, large abdominal aortic or iliac aneurysm, and coagulation abnormality

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Strictures or other abnormalities preventing passage of the scope
- Barium swallow or upper gastrointestinal (GI) series within the preceding 48 hr
- Severe lower GI bleeding or the presence of feces, barium, blood, or blood clots

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Use of bowel preparations that include laxatives or enemas should be avoided in pregnant patients or patients with inflammatory bowel disease, unless specifically directed by a health care provider (HCP).

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient the test is primarily used to examine the rectum and the distal portion of the colon.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, and anesthetics.
- ♦ Obtain a history of the patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results. Ensure that this procedure is performed before an upper GI study or barium swallow.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note time and date of last dose.
- ♦ Note intake of oral iron preparations within 1 wk before the procedure because these cause black, sticky feces that are difficult to remove with bowel preparation.
- ♦ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to insertion of the anoscope. Inform the patient that the procedure is performed in a GI lab by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ♦ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ Instruct the patient that a laxative may be needed the day before the procedure, with cleansing enemas on the morning of the procedure, depending on the institution's policy.
- ▶ Inform the patient that the urge to defecate may be experienced when the scope is passed. Encourage slow, deep breathing through the mouth to help alleviate the feeling.
- ▶ Inform the patient that flatus may be expelled during and after the procedure owing to air that is injected into the scope to improve visualization.
- ▶ Instruct the patient to eat a low-residue diet for 3 days prior to the procedure. Consume clear liquids only the evening before, and restrict food and fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with food, fluid, and medication restrictions and pretesting preparations.
- ▶ Administer two small-volume enemas 1 hr before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and change into the gown, robe, and foot coverings provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Wear gloves and gown throughout the procedure.
- ▶ Record baseline vital signs and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Place the patient on an examination table in the left lateral decubitus position or the knee-chest position and drape with the buttocks exposed. The buttocks are placed at or extending slightly beyond the edge of the examination table or bed, preferably on a special examining table that tilts the patient into the desired position.
- ▶ The HCP visually inspects the perianal area and then performs a digital rectal examination with a well-lubricated, gloved finger. A fecal specimen may be obtained from the glove when the finger is removed from the rectum.

- ▶ A lubricated anoscope (7 cm in length) is inserted, and the anal canal is inspected (anoscopy). The anoscope is removed, and a lubricated proctoscope (27 cm in length) or flexible sigmoidoscope (35 to 60 cm in length) is inserted.
- ▶ The scope is manipulated gently to facilitate passage, and air may be insufflated through the scope to improve visualization. Suction and cotton swabs also are used to remove materials that hinder visualization.
- ▶ The patient is instructed to take deep breaths to aid in movement of the scope downward through the ascending colon to the cecum and into the terminal portion of the ileum.
- ▶ Examination is done as the scope is gradually withdrawn. Photographs are obtained for future reference.
- ▶ At the end of the procedure, the scope is completely withdrawn, and residual lubricant is cleaned from the anal area.
- ▶ Place fecal or tissue samples and polyps in properly labeled specimen containers, and promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Monitor temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature changes. Protocols may vary from facility to facility.
- ▶ Monitor for any rectal bleeding.
- ▶ Instruct the patient to resume diet, medication, and activity, as directed by the HCP.
- ▶ Instruct the patient to expect slight rectal bleeding for 2 days after removal of polyps or biopsy specimens, but that heavy rectal bleeding must be immediately reported to the HCP.
- ▶ Instruct the patient that any abdominal pain, tenderness, or distention; pain on defecation; or fever must be reported to the HCP immediately.
- ▶ Inform the patient that any bloating or flatulence is the result of air insufflation.
- ▶ Encourage the patient to drink several glasses of water to help replace fluid lost during test preparation.

- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include barium enema, capsule endoscopy, colonoscopy, complete blood count, CT abdomen, fecal analysis, fecal fat, GI blood loss scan, MRI abdomen, and US prostate transrectal.
- ▶ Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Progesterone

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunochemiluminometric assay [ICMA])

Hormonal State	Conventional Units	SI Units (Conventional Units × 3.18)
Prepubertal	7–52 ng/dL	0.2–1.7 nmol/L
Adult Male	13–97 ng/dL	0.4–3.1 nmol/L
Adult Female		
<i>Follicular phase</i>	15–70 ng/dL	0.5–2.2 nmol/L
<i>Luteal phase</i>	200–2500 ng/dL	6.4–79.5 nmol/L
<i>Pregnancy,</i>		
<i>first trimester</i>	725–4400 ng/dL	23.0–140.0 nmol/L
<i>Pregnancy,</i>		
<i>second trimester</i>	1950–8250 ng/dL	62.0–262.4 nmol/L
<i>Pregnancy,</i>		
<i>third trimester</i>	6500–22,900 ng/dL	206.7–728.2 nmol/L
<i>Postmenopausal period</i>	Less than 40 ng/dL	Less than 127.2 nmol/L

DESCRIPTION: Progesterone is a female sex hormone. Its function is to prepare the uterus for pregnancy and the breasts for lactation. Progesterone testing can be used to confirm that

ovulation has occurred and to assess the functioning of the corpus luteum. Serial measurements can be performed to help determine the day of ovulation.

INDICATIONS:

- Assist in the diagnosis of luteal-phase defects (performed in conjunction with endometrial biopsy)
- Evaluate patients at risk for early or spontaneous abortion
- Identify patients at risk for ectopic pregnancy and assessment of corpus luteum function
- Monitor patients ovulating during the induction of human chorionic gonadotropin (HCG), human menopausal gonadotropin, follicle-stimulating hormone/luteinizing hormone-releasing hormone, or clomiphene (serial measurements can assist in pinpointing the day of ovulation)
- Monitor patients receiving progesterone replacement therapy

RESULT:

Increased in:

- Chorioepithelioma of the ovary (**Progesterone-secreting tumor**)
- Congenital adrenal hyperplasia (**Excessive production of progesterone precursors**)
- Hydatidiform mole (**Progesterone-secreting tumor**)
- Lipoid ovarian tumor (**Progesterone-secreting tumor**)
- Theca lutein cyst (**Progesterone-secreting cyst**)

Decreased in:

- Galactorrhea-amenorrhea syndrome (**Progesterone is not produced in the absence of ovulation**)
- Primary or secondary hypogonadism (**Diminished production of progesterone**)
- Short luteal phase syndrome (**Diminished time frame for production and secretion**)
- Threatened abortion (**Decreased production by threatened placenta**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase progesterone levels include clomiphene, corticotropin, hydroxyprogesterone, ketoconazole, mifepristone, progesterone, tamoxifen, and valproic acid.
- Drugs that may decrease progesterone levels include ampicillin, epostane, goserelin, leuprolide, and prostaglandin F2a.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to assess ovarian function, assist in fertility work-ups, and monitor placental function during pregnancy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

P

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and provide support. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide a nonjudgmental, nonthreatening atmosphere

for exploring other options (e.g., adoption). Educate the patient regarding access to counseling services, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, AFP, amniotic fluid analysis, antibodies cardioliipin, biopsy chorionic villus, estradiol, fetal fibronectin, FSH, HCG, LH, prolactin, testosterone, and US BPP obstetric.
- ▶ Refer to the Endocrine and Reproductive System tables at the back of the book for related tests by body system.

Prolactin

SYNONYM/ACRONYM: Luteotropic hormone, lactogenic hormone, lactogen, HPRL, PRL.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Specimen should be transported tightly capped and in an ice slurry.

REFERENCE VALUE: (Method: Immunoassay)

Age	Conventional Units	SI Units (Conventional Units × 1)
Prepubertal males and females	3.2–20.0 ng/mL	3.2–20.0 mcg/L
Men	4.0–23.0 ng/mL	4.0–23.0 mcg/L
Women	4.0–30.0 ng/mL	4.0–30.0 mcg/L
<i>Pregnant</i>	5.3–215.3 ng/mL	5.3–215.3 mcg/L
<i>Postmenopausal</i>	2.4–24.0 ng/mL	2.4–24.0 mcg/L

DESCRIPTION: Prolactin is secreted by the pituitary gland. It is unique among hormones in that it responds to inhibition by the hypothalamus rather than to stimulation. The only known function of prolactin is to induce milk production in female breasts that are already stimulated by high estrogen levels. When milk production is established, lactation can continue without elevated prolactin levels. Prolactin levels rise late in pregnancy, peak with the initiation of lactation, and surge each time a woman breast-feeds. The function of prolactin in males is unknown.

INDICATIONS:

- Assist in the diagnosis of primary hypothyroidism, as indicated by elevated levels
- Assist in the diagnosis of suspected tumor involving the lungs or kidneys (elevated levels indicating ectopic prolactin production)
- Evaluate failure of lactation in the postpartum period
- Evaluate sexual dysfunction of unknown cause in men and women
- Evaluate suspected postpartum hypophyseal infarction (Sheehan's syndrome), as indicated by decreased levels

RESULT:

Increased in:

- Adrenal insufficiency (**Secondary to hypopituitarism**)
- Amenorrhea (**Pathophysiology is not well understood**)
- Anorexia nervosa (**Pathophysiology is not well understood**)
- Breastfeeding (**Stimulates secretion of prolactin**)
- Chiari-Frommel and Argonz-Del Castillo syndromes (**Endocrine disorders in which pituitary or**

hypothalamic tumors secrete excessive amounts of prolactin)

- Chest wall injury (**Trauma in this location can stimulate production of prolactin**)
- Chronic renal failure (**Related to decreased renal excretion**)
- Ectopic prolactin-secreting tumors (e.g., lung, kidney)
- Galactorrhea (**Production of breast milk related to prolactin-secreting tumor**)
- Hypothalamic and pituitary disorders
- Hypothyroidism (primary) (**Related to pituitary gland dysfunction**)
- Insulin-induced hypoglycemia (**Insulin affects the release of pituitary hormones including prolactin**)
- Liver failure
- Pituitary tumor
- Polycystic ovary (Stein-Leventhal) syndrome
- Pregnancy
- Surgery (pituitary stalk section)

Decreased in:

- Sheehan's syndrome (**Severe hemorrhage after obstetric delivery that causes pituitary infarct; secretion of all pituitary hormones is diminished**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and hormones that may increase prolactin levels include amitriptyline, amoxapine, arginine, azosemide, benserazide, butaperazine, butorphanol, carbidopa, chlorophenylpiperazine, chlorpromazine, cimetidine, clomipramine, desipramine, diethylstilbestrol, β -endorphin, enflurane, fenfluramine, fenoldopam, flunarizine, fluphenazine, growth hormone-releasing hormone, imipramine, insulin, interferon- β , labetalol, loxapine, megestrol, mestranol,

methyl dopa, metoclopramide, molindone, morphine, nitrous oxide, oral contraceptives, oxcarbazepine, parathyroid hormone, pentagastrin, perphenazine, phenothiazines, phenytoin, pimozide, prochlorperazine, promazine, ranitidine, remoxipride, reserpine, sulpiride, sultopride, thiethylperazine, thioridazine, thiothixene, thyrotropin-releasing hormone, trifluoperazine, trimipramine, tumor necrosis factor, veralipride, verapamil, and zometapine.

- Drugs and hormones that may decrease prolactin levels include anticonvulsants, apomorphine, bromocriptine, cabergoline, calcitonin, cyclosporine, dexamethasone, dopamine, D-Trp-6-LHRH, levodopa, metoclopramide, morphine, nifedipine, octreotide, pergolide, ranitidine, rifampin, ritanserlin, ropinirole, secretin, terguride, and thyroid hormones.
- Episodic elevations can occur in response to sleep, stress, exercise, hypoglycemia, and breastfeeding.
- Venipuncture can cause falsely elevated levels.
- Prolactin secretion is subject to diurnal variation, with highest levels occurring in the morning.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is primarily used to evaluate lactation disorders and identify the presence of prolactin-secreting tumors.
- ◆ Obtain a history of the patient's complaints, including a list of known

allergens, especially allergies or sensitivities to latex.

- ◆ Obtain a history of the patient's endocrine and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Specimen collection should occur between 8 and 10 a.m. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain there may be some discomfort during the venipuncture.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ The patient should fast for 12 hr before specimen collection.
- ◆ There are no fluid or medication restrictions, unless by medical direction.
- ◆ Prepare an ice slurry in a cup or plastic bag to have on hand for immediate transport of the specimen to the laboratory.

INTRATEST:

- ◆ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 12 hr prior to the procedure.
- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

The specimen should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACE, BMD, CT pituitary, DHEAS, estradiol, FSH, GH, HCG, insulin, laparoscopy gynecologic, LH, MRI pituitary, progesterone, RAIU, TSH, and thyroxine.
- ▶ Refer to the Endocrine and Reproductive System tables at the back of the book for related tests by body system.

Prostate-Specific Antigen

SYNONYM/ACRONYM: PSA.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Gender	Conventional Units	SI Units (Conventional Units × 1)
Male	Less than 4 ng/mL	Less than 4 mcg/L
Female	Less than 0.5 ng/mL	Less than 0.5 mcg/L

DESCRIPTION: Prostate-specific antigen (PSA) is produced exclusively by the epithelial cells of the prostate, periurethral, and perirectal glands. Used in conjunction with the digital rectal examination (DRE), PSA is a useful test for identifying and monitoring cancer of the prostate. PSA circulates in both free and bound (complexed) forms. A low ratio of free to complexed PSA (i.e., less than 10%) is suggestive of prostate

cancer; a ratio of greater than 30% is rarely associated with prostate cancer. Serial measurements are often performed before and after surgery. PSA velocity, the rate of PSA increase over time, is being used to identify the potential aggressiveness of the cancer. Patients with an increase greater than 2.0 ng/mL in a year are more likely to have an aggressive form of prostate cancer with a greater risk of death. PSA is also produced in



females, most notably in breast tissue. There is some evidence that elevated PSA levels in breast cancer patients are associated with positive estrogen and progesterone status. *Important note:* When following patients using serial testing, the same method of measurement should be consistently used.

INDICATIONS:

- Evaluate the effectiveness of treatment for prostate cancer (prostatectomy): Levels decrease if treatment is effective; rising levels are associated with recurrence and a poor prognosis.
- Investigate or evaluate an enlarged prostate gland, especially if prostate cancer is suspected.
- Stage prostate cancer.

RESULT:

Increased in:

- ***A breach in the protective barrier between the prostatic lumen and the bloodstream due to significant disease will allow measurable levels of circulating PSA.***
- Benign prostatic hypertrophy
- Prostate cancer
- Prostatic infarct
- Prostatitis
- Urinary retention

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that decrease PSA levels include buserelin, dutasteride, finasteride, and flutamide.
- Increases may occur if ejaculation occurs within 24 hr prior to specimen collection. Increases can occur due to prostatic needle biopsy, cytoscopy, prostatic infarction either by undergoing catheterization or

the presence of an indwelling catheter, therefore specimens should be collected prior to or 6 wk after the procedure. There is conflicting information regarding the effect of DRE on PSA values and some health care providers (HCPs) may specifically request specimen collection prior to DRE.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to monitor status of prostate cancer and response to therapy.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's genitourinary, immune, and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the

patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and offer support. Counsel the patient, as appropriate, that sexual dysfunction related to altered body function, drugs, or radiation may occur. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the

National Cancer Institute (www.cancer.gov).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family. The National Cancer Society's recommendations and American Urological Society's Best Practice Policy on prostate cancer include annual screening for men over age 49 yr. Recommendations for men with an increased risk, such as African American males or males with a family history of prostate cancer, include annual screening over age 39 yr.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy prostate (including Gleason Score), cystoscopy, cystourethrography voiding, PAP, retrograde ureteropyelography, semen analysis, and US prostate.
- ▶ Refer to the Genitourinary, Immune, and Reproductive System tables at the back of the book for related tests by body system.

Protein, Blood, Total and Fractions

SYNONYM/ACRONYM: TP, SPEP (fractions include albumin, α_1 -globulin, α_2 -globulin, β -globulin, and γ -globulin).

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Spectrophotometry for total protein, electrophoresis for protein fractions)

Total Protein

Age	Conventional Units	SI Units (Conventional Units × 10)
Newborn–5 d	3.8–6.2 g/dL	38–62 g/L
1–3 yr	5.9–7.0 g/dL	59–70 g/L
4–6 yr	5.9–7.8 g/dL	59–78 g/L
7–9 yr	6.2–8.1 g/dL	62–81 g/L
10–19 yr	6.3–8.6 g/dL	63–86 g/L
Adult	6.0–8.0 g/dL	60–80 g/L

Protein Fractions

	Conventional Units	SI Units (Conventional Units × 10)
Albumin	3.4–4.8 g/dL	34–48 g/L
α_1 -Globulin	0.2–0.4 g/dL	2–4 g/L
α_2 -Globulin	0.4–0.8 g/dL	4–8 g/L
β -Globulin	0.5–1.0 g/dL	5–10 g/L
γ -Globulin	0.6–1.2 g/dL	6–12 g/L

DESCRIPTION: Protein is essential to all physiological functions. Proteins consist of amino acids, the building blocks of blood and body tissues. Protein is also required for the regulation of metabolic processes, immunity, and proper water balance. Total protein includes albumin and globulins. α_1 -Globulin includes α_1 -antitrypsin, α_1 -fetoprotein, α_1 -acid glycoprotein, α_1 -antichymotrypsin, inter- α_1 -trypsin inhibitor, high-density lipoproteins, and group-specific component (vitamin D-binding protein). α_2 -Globulin includes haptoglobin, ceruloplasmin, and α_2 -macroglobulin. β -Globulin includes transferrin, hemopexin, very-low-density lipoproteins, low-density lipoproteins, β_2 -microglobulin, fibrinogen, complement, and C-reactive protein. γ -Globulin includes immunoglobulin (Ig) G, IgA, IgM, IgD, and IgE. After an acute infection or trauma, levels of many of the

liver-derived proteins increase, whereas albumin level decreases; these conditions may not reflect an abnormal total protein determination.

INDICATIONS:

- Evaluation of edema, as seen in patients with low total protein and low albumin levels
- Evaluation of nutritional status

RESULT:

Increased in:

- α_1 -Globulin proteins in acute and chronic inflammatory diseases
- α_2 -Globulin proteins occasionally in diabetes, pancreatitis, and hemolysis
- β -Globulin proteins in hyperlipoproteinemias and monoclonal gammopathies
- γ -Globulin proteins in chronic liver diseases, chronic infections, autoimmune disorders, hepatitis, cirrhosis, and lymphoproliferative disorders

- Total protein:
 - Dehydration (**Hemoconcentration**)
 - Monoclonal and polyclonal gammopathies (**Excessive gamma globulin protein synthesis**)
 - Myeloma (**Excessive gamma globulin protein synthesis**)
 - Sarcoidosis (**Mostly gamma globulins**)
 - Some types of chronic liver disease
 - Tropical diseases (e.g., leprosy) (**Related to inflammatory reaction**)
 - Waldenström's macroglobulinemia (**Mostly gamma globulins**)

Decreased in:

- α_1 -Globulin proteins in hereditary deficiency
- α_2 -Globulin proteins in nephrotic syndrome, malignancies, numerous subacute and chronic inflammatory disorders, and recovery stage of severe burns
- β -Globulin proteins in hypo-b-lipoproteinemias and IgA deficiency
- γ -Globulin proteins in immune deficiency or suppression
- Total protein:
 - Administration of IV fluids (**Hemodilution**)
 - Burns (**Related to fluid retention, loss of albumin from chronic open burns**)
 - Chronic alcoholism (**Related to insufficient dietary intake; diminished protein synthesis by damaged liver**)
 - Chronic ulcerative colitis (**Related to poor intestinal absorption**)
 - Cirrhosis (**Damaged liver cannot synthesize adequate amount of protein**)
 - Crohn's disease (**Related to poor intestinal absorption**)
 - Glomerulonephritis (**Related to alteration in permeability that results in excessive loss by kidneys**)
 - Heart failure (**Related to fluid retention**)
 - Hyperthyroidism (**Possibly related to increased metabolism and corresponding protein synthesis**)
 - Malabsorption (**Insufficient intestinal absorption**)
 - Malnutrition (**Insufficient intake**)
 - Neoplasms
 - Nephrotic syndrome (**Related to alteration in permeability that results in excessive loss by kidneys**)

- Pregnancy (**Related to fluid retention, dietary insufficiency, increased demands of growing fetus**)
- Prolonged immobilization (**Related to fluid retention**)
- Protein-losing enteropathies (**Related to excessive loss**)
- Severe skin disease
- Starvation (**Insufficient intake**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase protein levels include amino acids (if given IV), anabolic steroids, angiotensin, anticonvulsants, carbenicillin, corticosteroids, corticotropin, digitalis, furosemide, insulin, isotretinoin, levonorgestrel, oral contraceptives, progesterone, radiographic agents, and thyroid agents.
- Drugs and substances that may decrease protein levels include acetylsalicylic acid, arginine, benzene, carvedilol, citrates, floxuridine, laxatives, mercury compounds, oral contraceptives, pentastarch, phosgene, pyrazinamide, rifampin, trimethadione, and valproic acid.
- Values are significantly lower (5% to 10%) in recumbent patients.
- Hemolysis can falsely elevate results.
- Venous stasis can falsely elevate results; the tourniquet should not be left on the arm for longer than 60 sec.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to evaluate nutritional status; abnormal values are found in numerous conditions and diseases.

- ◆ Obtain a history of the patient's complaints, including a list of known allergens especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's gastrointestinal, hepatobiliary, and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ *Nutritional considerations*: Educate the patient, as appropriate, that good dietary sources of complete protein (containing all eight essential amino acids) include meat, fish, eggs, and dairy products; and that good sources of incomplete protein (lacking one or more of the eight essential amino acids) include grains, nuts, legumes, vegetables, and seeds.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include albumin, ALP, ACE, anion gap, AST, biopsy liver, biopsy lung, calcium, carbon dioxide, chloride, complete blood count, complete blood count, WBC count and differential, cryoglobulin, fecal analysis, fecal fat, gallium scan, GGT, IgA, IgG, IgM, IFE, liver and spleen scan, magnesium, mediastinoscopy, β_2 -microglobulin, osmolality, protein urine total and fractions, PFT, radiography bone, RF, sodium, TSH, thyroxine, and UA.
- ◆ Refer to the Gastrointestinal, Hepatobiliary, and Immune System tables at the back of the book for related tests by body system.

Protein C

SYNONYM/ACRONYM: Protein C antigen, protein C functional.

SPECIMEN: Plasma (1 mL) collected in blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Chromogenic) 70% to 140% activity. Values are significantly reduced in children because of liver immaturity.

DESCRIPTION: Protein C is a vitamin K–dependent protein that originates in the liver and circulates in plasma. Protein C activation occurs on thrombomodulin receptors on the endothelial cell surface. Thrombin bound to thrombomodulin receptors preferentially activates protein C. Freely circulating thrombin mainly converts fibrinogen to fibrin. Other steps in the activation process require calcium and protein S cofactor binding (see monographs titled “Protein S” and “Fibrinogen”). Activated protein C exhibits potent anticoagulant effects by degrading activated factors V and VIII. Factor V Leiden is a genetic variant of Factor V and is resistant to inactivation by protein C. Factor V Leiden is the most common inherited hypercoagulability disorder identified among individuals of Eurasian descent. There are two types of protein C deficiency:

Type I: Decreased antigen and function, detected by functional and antigenic assays

Type II: Normal antigen but decreased function, detected only by a functional assay

Functional assays are recommended for initial evaluation because of their greater sensitivity.

INDICATIONS:

- Differentiate inherited deficiency from acquired deficiency
- Investigate the mechanism of idiopathic venous thrombosis

RESULT:

Increased in: N/A

Decreased in:

- Congenital deficiency
- Liver disease (**Related to decreased synthesis by the liver**)
- Oral anticoagulant therapy (**Patients deficient in protein C may be at risk of developing Coumadin®-induced skin necrosis**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase protein C levels include desmopressin and oral contraceptives.
- Drugs that may decrease protein C levels include coumarin and warfarin (Coumadin).
- Placement of tourniquet for longer than 1 min can result in venous stasis and changes in the concentration of plasma proteins to be measured. Platelet activation may also occur under these conditions, causing erroneous results.
- Vascular injury during phlebotomy can activate platelets and coagulation factors, causing erroneous results.

- Hemolyzed specimens must be rejected because hemolysis is an indication of platelet and coagulation factor activation.
- Incompletely filled tubes contaminated with heparin or clotted specimens must be rejected.
- Icteric or lipemic specimens interfere with optical testing methods, producing erroneous results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess anticoagulant function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in

Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection.

Perform a venipuncture. **Important**

note: Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range.

- ▶ When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with tissue thromboplastin, which can falsely decrease values.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed samples stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection. If the patient has a known hematocrit above 55%, adjust the amount of anticoagulant in the collection tube before drawing the blood according to the CLSI guidelines:

$$\text{Anticoagulant vol. [x]} = (100 - \text{hematocrit}) / (595 - \text{hematocrit}) \times \text{total vol. of anticoagulated blood required}$$

Example:

$$\text{Patient hematocrit} = 60\% \quad (100 - 60) / (595 - 60) \times 5.0 = 0.37 \text{ mL sodium citrate for a 5-mL standard drawing tube}$$

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and

determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibody, anticardiolipin, antithrombin III, calcium, complete blood count, coagulation factors (factor V), FDP, fibrinogen, lupus anticoagulant, aPTT, protein S, PT/INR, and vitamin K.
- ▶ Refer to the Hematopoietic and Hepatobiliary System tables at the back of the book for related tests by body system.

Protein S

SYNONYM/ACRONYM: Protein S antigen, protein S functional.

SPECIMEN: Plasma (1 mL) collected in blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Clot detection)

	Conventional Units
Total proteins	70–140% activity
Free proteins	60–120% activity

Note: The low end of "normal" is lower in children younger than age 16 because of the immaturity of the liver.

DESCRIPTION: Protein S is a vitamin K–dependent protein that originates in the liver and circulates in plasma. It is a cofactor required for the activation of protein C (see monographs titled "Protein C" and "Fibrinogen"). Protein S exists in two forms, free (biologically active) and bound. Approximately 40% of protein S circulates in the free form; the remainder is bound and is functionally inactive. There are two types of protein S deficiency:

Type I: Decreased antigen and function, detected by functional and antigenic assays

Type II: Normal antigen but decreased function, detected only by a functional assay

Functional assays are recommended for initial evaluation because of their greater sensitivity.

INDICATIONS:

Investigate the cause of hypercoagulable states.

RESULT:

Increased in: N/A

Decreased in:

- Congenital deficiency
- Disseminated intravascular coagulation (DIC) (**Consumed in DIC**)

- Liver disease (**Related to decreased synthesis by the liver**)
- Oral anticoagulant therapy

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may decrease protein S levels include coumarin, oral contraceptives, and warfarin (Coumadin®).
- Placement of tourniquet for longer than 1 min can result in venous stasis and changes in the concentration of plasma proteins to be measured. Platelet activation may also occur under these conditions, causing erroneous results.
- Vascular injury during phlebotomy can activate platelets and coagulation factors, causing erroneous results.
- Hemolyzed specimens must be rejected because hemolysis is an indication of platelet and coagulation factor activation.
- Incompletely filled tubes contaminated with heparin or clotted specimens must be rejected.
- Icteric or lipemic specimens interfere with optical testing methods, producing erroneous results.

NURSING IMPLICATIONS AND PROCEDURE

P

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess anticoagulant function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of medications the patient is taking, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. *Important note:* Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range.
- ▶ When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid contaminating the specimen with

tissue thromboplastin, which can falsely decrease values.

- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed samples stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection. If the patient has a known hematocrit above 55%, adjust the amount of anticoagulant in the collection tube before drawing the blood according to the CLSI guidelines:

$$\text{Anticoagulant vol. [x]} = \frac{(100 - \text{hematocrit})}{(595 - \text{hematocrit})} \times \text{total vol. of anticoagulated blood required}$$

Example:

$$\begin{aligned} \text{Patient hematocrit} &= 60\% \\ \frac{(100 - 60)}{(595 - 60)} \times 5.0 &= \\ 0.37 \text{ mL sodium citrate for a 5-mL} & \text{ standard drawing tube} \end{aligned}$$

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related laboratory tests include, anticardiolipin antibody, AT-III, calcium, complete blood count, coagulation factors (factor V), FDP, fibrinogen, lupus anticoagulant, aPTT, protein C, PT/INR, and vitamin K.
- Refer to the Hematopoietic and Hepatobiliary System tables at the back of the book for related test by body system.

Protein, Urine: Total Quantitative and Fractions

P

SYNONYM/ACRONYM: None.

SPECIMEN: Urine (5 mL) from an unpreserved random or timed specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Spectrophotometry for total protein, electrophoresis for protein fractions)

	Conventional Units	SI Units (Conventional Units × 0.001)
Total protein	30–150 mg/24 h	0.03–0.15 g/24 h

Electrophoresis for fractionation is qualitative: No monoclonal gammopathy detected. (Urine protein electrophoresis should be ordered along with serum protein electrophoresis.)

DESCRIPTION: Most proteins, with the exception of the immunoglobulins, are synthesized and catabolized in the liver, where they are broken down into amino acids. The amino acids are converted to ammonia and ketoacids. Ammonia is converted to urea via the urea cycle. Urea is excreted in the urine.

INDICATIONS:

- Assist in the detection of Bence Jones proteins (light chains)
- Assist in the diagnosis of myeloma, Waldenström's macroglobulinemia, lymphoma, and amyloidosis
- Evaluate kidney function

RESULT:

Increased in:

- Diabetic nephropathy (*Disease involving renal glomeruli affects increases permeability of protein*)
- Fanconi's syndrome (*Abnormal protein deposits in the kidney can cause Fanconi's syndrome*)
- Heavy metal poisoning (*Disease involving renal glomeruli affects increases permeability of protein*)
- Malignancies of the urinary tract (*The tumors secrete protein into the urine*)
- Monoclonal gammopathies (*Large amounts of Bence Jones protein light chains are excreted in the urine*)
- Multiple myeloma (*Large amounts of Bence Jones protein light chains are excreted in the urine*)
- Nephrotic syndrome (*Disease involving renal glomeruli increases permeability of protein*)
- Postexercise period (*Related to muscle exertion*)

- Preeclampsia (*Numerous factors contribute to increased permeability of the kidneys to protein*)
- Sickle cell disease (*Related to increased destruction of red blood cells and excretion of hemoglobin protein*)
- Urinary tract infections (*Disease involving renal glomeruli affects increases permeability of protein*)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may increase urine protein levels include acetaminophen, aminosalicylic acid, amphotericin B, ampicillin, antimony compounds, antipyrine, arsenicals, ascorbic acid, bacitracin, bismuth subsalicylate, bromate, capreomycin, captopril, carbamazepine, carbarsonne, carbenoxolone, carbutamide, cephaloglycin, cephaloridine, chlorpromazine, chlorpropamide, chlorthalidone, chrysoarobin, colistimethate, colistin, corticosteroids, cyclosporine, demeclocycline, 1, 2-diaminopropane, diatrizoic acid, dihydrotachysterol, doxycycline, enalapril, gentamicin, gold, hydrogen sulfide, iodoaliphonic acid, iodopyracet, iopanoic acid, iophenoxic acid, ipodate, kanamycin, corn oil (Lipomul), lithium, mefenamic acid, melarsonyl, melarsoprol, mercury compounds, methicillin, methylbromide, mezlocillin, mitomycin, nafcillin, naphthalene, neomycin, non-steroidal anti-inflammatory drugs, oxacillin, paraldehyde, penicillamine, penicillin, phenolphthalein, phenols, phensuximide, phosphorus, picric acid, piperacillin, plicamycin, polymyxin, probenecid, promazine, pyrazolones,

quaternary ammonium compounds, radiographic agents, rifampin, sodium bicarbonate, streptokinase, sulfisoxazole, suramin, tetracyclines, thallium, thiosemicarbazones, tolbutamide, tolmetin, triethylenemelamine, and vitamin D.

- Drugs that may decrease urine protein levels include captopril, cyclosporine, diltiazem, enalapril, fosinopril, interferon, lisinopril, prednisolone, and quinapril.
- All urine voided for the timed collection period must be included in the collection or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify the underlying cause for proteinuria.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and immune systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that

24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.

- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):

Clean-Catch Specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.

Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.

If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.

At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than the recorded output, some urine may have been discarded, invalidating the test.

Include on the collection container's label the amount of urine collected and test start and stop times.

General:

Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related laboratory tests include amino acid screen, ACE, β_2 -microglobulin, biopsy bladder, biopsy bone marrow, bladder cancer markers, BUN, calcium, complete blood count, CT pelvis, CT renal, creatinine, cryoglobulin, culture urine, cytology urine, cystometry, cystoscopy, glucose, glycated hemoglobin, Hgb electrophoresis, IgA, IgG, IgM, IFE, IVP, lead, LAP, MRI musculoskeletal, microalbumin, osmolality, porphyrins, protein blood total and fractions, renogram, sickle cell screen, US bladder, US spleen, UA, and voiding cystourethrography.
- ▶ Refer to the Genitourinary and Immune System tables at the back of the book for related tests by body system.

Prothrombin Time and International Normalized Ratio

SYNONYM/ACRONYM: Protime, PT.

SPECIMEN: Plasma (1 mL) collected in a completely filled blue-top (sodium citrate) tube.

REFERENCE VALUE: (Method: Clot detection) 10 to 13 sec.

International Normalized Ratio (INR) = Less than 2.0 for patients not receiving anticoagulation therapy, 2.0 to 3.0 for patients receiving treatment for venous thrombosis, pulmonary embolism, and valvular heart disease.

INR = 2.5 to 3.5 for patients with mechanical heart valves and/or receiving treatment for recurrent systemic embolism.

DESCRIPTION: Prothrombin time (PT) is a coagulation test performed to measure the time it takes for a firm fibrin clot to form after tissue thromboplastin (factor III) and calcium are added to the sample. It is used to evaluate the extrinsic pathway of the coagulation sequence in patients receiving oral warfarin or coumarin-type anticoagulants. Prothrombin is a vitamin K-dependent protein produced by the liver; measurement is reported as time in seconds or percentage of normal activity.

The goal of long-term anticoagulation therapy is to achieve a balance between *in vivo* thrombus formation and hemorrhage. It is a delicate clinical balance and due to differences in instruments and reagents there is a wide variation in PT results between laboratories. Worldwide concern for the need to provide more consistency in monitoring patients receiving anticoagulant therapy led to the development of an international committee. In the early 1980s, manufacturers of

instruments and reagents began comparing their measurement systems with a single reference material provided by the World Health Organization (WHO). The international effort successfully developed an algorithm to provide comparable PT values regardless of differences in laboratory methodology. Reagent and instrument manufacturers compare their results to the WHO reference and derive a factor called an International Sensitivity Index (ISI) that is applied to a mathematical formula to standardize the results. Laboratories convert their PT values into an International Normalized Ratio (INR) by using the following formula:

$$\text{INR} = \left(\frac{\text{patient PT result}}{\text{patient average}} \right)^{\text{ISI}}$$

PT evaluation can now be based on an INR using a standardized thromboplastin reagent to assist in making decisions regarding oral anticoagulation therapy.

Some inferences of factor deficiency can be made by

comparison of results obtained from the activated partial thromboplastin time (aPTT) and PT tests. A normal aPTT with a prolonged PT can occur only with factor VII deficiency. A prolonged aPTT with a normal PT could indicate a deficiency in factors XII, XI, IX, and VIII as well as VIII:C (von Willebrand factor). Factor deficiencies can also be identified by correction or substitution studies using normal serum. These studies are easy to perform and are accomplished by adding plasma from a normal patient to a sample from a suspected factor-deficient patient. When the PT is repeated and corrected, or within the reference range, it can be assumed that the prolonged PT is due to a factor deficiency (see monograph titled "Coagulation Factors"). If the result remains uncorrected, the prolonged PT is most likely due to a circulating anticoagulant.

INDICATIONS:

- Differentiate between deficiencies of clotting factors II, V, VII, and X, which prolong the PT; and congenital coagulation disorders, such as hemophilia A (factor VIII) and hemophilia B (factor IX), which do not alter the PT
- Evaluate the response to anticoagulant therapy with coumarin derivatives and determine dosage required to achieve therapeutic results
- Identify individuals who may be prone to bleeding during surgical, obstetric, dental, or invasive diagnostic procedures
- Identify the possible cause of abnormal bleeding, such as epistaxis, hematoma, gingival bleeding, hematuria, and menorrhagia
- Monitor the effects of conditions such as liver disease, protein

deficiency, and fat malabsorption on hemostasis

- Screen for prothrombin deficiency
- Screen for vitamin K deficiency

RESULT:

Increased in:

- Afibrinogenemia, dysfibrinogenemia, or hypofibrinogenemia (**Fibrinogen is required for clotting and its absence will prolong PT**)
- Biliary obstruction (**Related to poor absorption of fat-soluble vitamin K; vitamin K is required for clotting and its absence will prolong PT**)
- Disseminated intravascular coagulation (**Clotting factors are consumed and PT is prolonged**)
- Hereditary deficiencies of factors II, V, VII, and X (**Factors are required for clotting; in their absence PT will be prolonged**)
- Liver disease (cirrhosis) (**Clotting factors are made in the liver; decreased liver function will result in decreased production of clotting factors and prolonged PT**)
- Poor fat absorption (**Tropical sprue, celiac disease, chronic diarrhea are conditions that prevent absorption of fat-soluble vitamins including vitamin K which is required for clotting; absence of vitamin K will prolong PT**)
- Presence of circulating anticoagulant (**Inhibitors of specific factors, e.g., developed from long-term Factor VIII therapy or circulating anticoagulants associated with conditions like tuberculosis, systemic lupus erythematosus, rheumatoid arthritis, and chronic glomerulonephritis**)

- Vitamin K deficiency (**Vitamin K is required for clotting and its absence will prolong PT**)

Decreased in:

- Ovarian hyperfunction
- Regional enteritis or ileitis

CRITICAL VALUES:

INR:

Greater than 5

Prothrombin Time:

Greater than 27 sec

Note and immediately report to the health care provider (HCP) any critically increased values and related symptoms. Important signs to note are prolonged bleeding from cuts or gums, hematoma at a puncture site, hemorrhage, blood in the stool, persistent epistaxis, heavy or prolonged menstrual flow, and shock. Monitor vital signs, unusual ecchymosis, occult blood, severe headache, unusual dizziness, and neurological changes until PT is within normal range. Intramuscular administration of vitamin K, an anticoagulant reversal agent, may be requested by the HCP.

INTERFERING FACTORS:

- Drugs that may increase the PT in patients receiving anticoagulation therapy include acetaminophen, acetylsalicylic acid, amiodarone, anabolic steroids, anisindione, anistreplase, antibiotics, antipyrine, carbenicillin, cathartics, chlorthalidone, cholestyramine, clofibrate, corticotropin, demeclocycline, dextrothyroxine, diazoxide, diflunisal, diuretics, doxycycline, erythromycin, glucagon, hydroxyzine, indomethacin, laxatives, mercaptopurine, miconazole, nalidixic acid, neomycin, niacin, oxyphenbutazone, phenytoin, quinine, sulfachlorpyridazine, and thyroxine.
- Drugs that may decrease the PT in patients receiving anticoagulation therapy include amobarbital,

- anabolic steroids, antacids, antihistamines, barbiturates, carbamazepine, chloral hydrate, chlordane, colchicine, corticosteroids, diuretics, oral contraceptives, penicillin, primidone, rifampin, simethicone, spironolactone, tolbutamide, and vitamin K.
- Traumatic venipunctures can activate the coagulation sequence by contaminating the sample with tissue thromboplastin, and producing falsely shortened PT.
- Failure to fill the tube sufficiently to yield proper blood-to-anticoagulant ratio may cause a falsely lengthened PT; an incompletely filled tube is reason for specimen rejection.
- Excessive agitation causing sample hemolysis can falsely shorten the PT because the hemolyzed cells activate plasma-clotting factors.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate the coagulation system and monitor anticoagulation therapy.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's cardiovascular, hematopoietic, and hepatobiliary systems, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests, diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number

of days prior to a surgical procedure. Note the last time and dose of medication taken.

- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. Fill tube completely. **Important note:** Two different concentrations of sodium citrate preservative are currently added to blue-top tubes for coagulation studies: 3.2% and 3.8%. The Clinical and Laboratory Standards Institute/CLSI (formerly the National Committee for Clinical Laboratory Standards/NCCLS) guideline for sodium citrate is 3.2%. Laboratories establish reference ranges for coagulation testing based on numerous factors, including sodium citrate concentration, test equipment, and test reagents. It is important to ask the laboratory which concentration it recommends, because each concentration will have its own specific reference range.
- ▶ When multiple specimens are drawn, the blue-top tube should be collected after sterile (i.e., blood culture) and red-top tubes. When coagulation testing is the only work to be done, an extra red-top tube should be collected before the blue-top tube to avoid

contaminating the specimen with tissue thromboplastin, which can falsely shorten PT/INR.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis. The CLSI recommendation for processed and unprocessed samples stored in unopened tubes is that testing should be completed within 1 to 4 hr of collection.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to report bleeding from any areas of the skin or mucous membranes.
- ▶ Inform the patient with prolonged PT/INR of the importance of taking precautions against bruising and bleeding, including the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of aspirin products, and avoidance of intramuscular injections.
- ▶ Inform the patient of the importance of periodic laboratory testing while taking an anticoagulant.
- ▶ **Nutritional considerations:** Foods high in vitamin K should be avoided by the patient on anticoagulant therapy. Foods that contain vitamin K include cabbage, cauliflower, chickpeas, egg yolks, green tea, liver, milk, soybean products, tomatoes, and green leafy vegetables such as brussels sprouts, kale, spinach, and turnip greens.
- ▶ **Nutritional considerations:** Avoid alcohol and alcohol products while taking warfarin, as the combination of the two increases the risk of gastrointestinal bleeding.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process

and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include, ALP, ALT, ANA, AT-III, AST, bilirubin, biopsy liver, bleeding time, calcium, coagulation factors, complete blood count, complete blood count, platelet count, CT liver and

biliary tract, cryoglobulin, D-dimer, fecal analysis, fecal fat, FDP, fibrinogen, GGT, gastric acid emptying scan, hepatitis antibodies (A, B, C, D), liver and spleen scan, lupus anticoagulant, aPTT, plasminogen, protein C, protein S, US liver, and vitamin K.

Refer to the Cardiovascular, Hematopoietic, and Hepatobiliary System tables at the back of the book for related tests by body system.

Pseudocholinesterase and Dibucaine Number

SYNONYM/ACRONYM: CHS, PCHE, AcCHS.

SPECIMEN: Plasma (1 mL) collected in a lavender-top (EDTA) tube. Serum (1 mL) collected in a red-top tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry, kinetic)

Test	Conventional Units	SI Units (Conventional Units × 1)
Pseudocholinesterase	2–11 units/mL	2–11 kU/L

Dibucaine Number	Fraction (%) of Activity Inhibited	SI Units (Conventional Units × 0.01)
Normal homozygote	79%–84%	0.79–0.84 kU/L
Heterozygote	55%–70%	0.55–0.70 kU/L
Abnormal homozygote	16%–28%	0.16–0.28 kU/L

RESULT:

Increased in:

Increased levels are observed in a number of conditions without specific cause.

- Diabetes
- Hyperthyroidism
- Nephrotic syndrome
- Obesity

Decreased in:

The enzyme is produced in the liver and any condition affecting liver function may result in decreased production of circulating enzyme.

- Acute infection
- Anemia (severe)
- Carcinomatosis
- Cirrhosis
- Congenital deficiency

- Hepatic carcinoma
- Hepatocellular disease
- Infectious hepatitis
- Insecticide exposure (**Organic phosphate exposure decreases enzyme activity**)
- Malnutrition (**Possibly related to decreased availability of transport proteins; condition associated with decreased enzyme activity**)
- Muscular dystrophy
- Myocardial infarction
- Plasmapheresis (**Iatrogenic cause**)
- Succinylcholine hypersensitivity (**This chemical is a trigger in susceptible individuals**)
- Tuberculosis (**Chronic infection is known to decrease enzyme activity**)
- Uremia (**Pathological condition is known to decrease enzyme activity**)

CRITICAL VALUES: 

Notify the anesthesiologist if the test result is positive and surgery is scheduled. A positive result indicates that the patient is at risk for prolonged or unrecoverable apnea related to the inability to metabolize succinylcholine.

Find and print out the full monograph at [DavisPlus \(davisplus.fadavis.com\)](http://davisplus.fadavis.com), keyword Van Leeuwen).

Pulmonary Function Studies

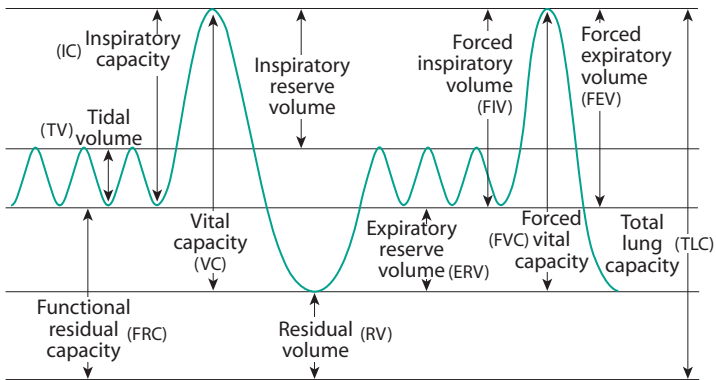
SYNONYM/ACRONYM: Pulmonary function tests (PFTs).

AREA OF APPLICATION: Lungs, respiratory system.

CONTRAST: None.

DESCRIPTION: Pulmonary function studies provide information about the volume, pattern, and rates of airflow involved in respiratory function. These studies may also include tests involving the diffusing capabilities of the lungs (i.e., volume of gases diffusing across a membrane). A complete pulmonary study profile includes the determination of all lung volumes, spirometry, diffusing capacity, maximum voluntary ventilation, flow-volume loop (Fig. 1–1), and maximum expiratory and inspiratory pressures. Other studies include small airway volumes.

Pulmonary function studies are classified according to lung volumes and capacities, rates of flow, and gas exchange. The exception is the diffusion test, which records the movement of a gas during inspiration and expiration. Lung volumes and capacities constitute the amount of air inhaled or exhaled from the lungs; this value is compared to normal reference values specific for the patient's age, height, and gender. The following are volumes and capacities measured by spirometry that do not require timed testing.

**Tidal Volume:**

Total amount of air inhaled and exhaled with one breathe.

Residual Volume:

Amount of air remaining in the lungs after a maximum expiration effort (not measured by spirometry, but can be calculated from the functional residual capacity [FRC] minus the expiratory reserve volume [ERV]). This indirect type of measurement can be done by body plethysmography (see monograph titled “Plethysmography”).

Inspiratory Reserve Volume:

Maximum amount of air inhaled after normal inspirations.

Expiratory Reserve Volume:

Maximum amount of air exhaled after a resting expiration (can be calculated by the vital capacity [VC] minus the inspiratory capacity [IC]).

Vital Capacity:

Maximum amount of air exhaled after a maximum inspiration (can be calculated by adding the IC and the ERV).

Total Lung Capacity:

Total amount of air that the lungs can hold after maximal inspiration (can be calculated by adding the VC and the residual volume [RV]).

Inspiratory Capacity:

Maximum amount of air inspired after normal expiration (can be calculated by adding the inspiratory RV and tidal volume).

Functional Residual Capacity:

Volume of air that remains in the lungs after normal expiration (can be calculated by adding the RV and ERV).

The volumes, capacities, and rates of flow measured by spirometry that do require timed testing include the following:

Forced Vital Capacity in 1 Second:

Maximum amount of air that can be forcefully exhaled after a full inspiration.

Forced Expiratory Volume:

Amount of air exhaled in the first second (can also be determined at 2 or 3 seconds) of forced vital capacity (FVC, which is the amount of air exhaled in seconds, expressed as a percentage).

Maximal Midexpiratory Flow:

Also known as forced expiratory flow rate (FEF₂₅₋₇₅), or the maximal rate of airflow during a forced expiration.

Forced Inspiratory Flow Rate:

Volume inspired from the RV at a point of measurement (can be

expressed as a percentage to identify the corresponding volume pressure and inspired volume).

Peak Inspiratory Flow Rate:

Maximum airflow during a forced maximal inspiration.

Peak Expiratory Flow Rate:

Maximum airflow expired during FVC.

Flow-Volume Loops:

Flows and volumes recorded during forced expiratory volume and forced inspiratory vital capacity procedures (Fig. 1–2).

Maximal Inspiratory-Expiratory Pressures:

Measures the strength of the respiratory muscles in neuromuscular disorders.

Maximal Voluntary Ventilation:

Maximal volume of air inspired and expired in 1 min (may be done for

shorter periods and multiplied to equal 1 min).

Other studies for gas-exchange capacity, small airway abnormalities, and allergic responses in hyperactive airway disorders can be performed during the conventional pulmonary function study. These include the following:

Diffusing Capacity of the Lungs:

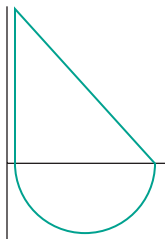
Rate of transfer of carbon monoxide through the alveolar and capillary membrane in 1 minute.

Closing Volume:

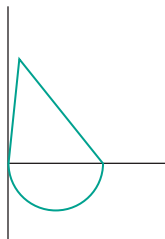
Measures the closure of small airways in the lower alveoli by monitoring volume and percentage of alveolar nitrogen after inhalation of 100% oxygen.

Isoflow Volume:

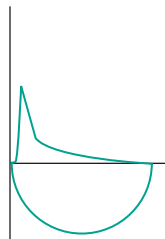
Flow-volume loop test followed by inhalation of a mixture of helium and oxygen to determine small airway disease.



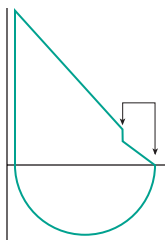
Normal



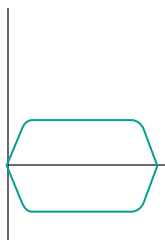
Restrictive



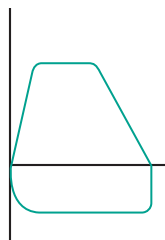
Obstructive



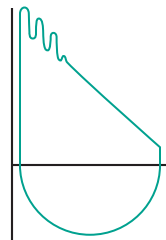
Small airway disease



Fixed upper airway obstruction



Variable upper airway obstruction



Sleep Apnea Disorder

Body Plethysmography:

Measures thoracic gas volume and airway resistance.

Bronchial Provocation:

Quantifies airway response after inhalation of methacholine.

Arterial Blood Gases:

Measure oxygen, pH, and carbon dioxide in arterial blood.

Values are expressed in units of mL, %, L, L/sec, and L/min, depending on the test performed.

INDICATIONS:

- Detect chronic obstructive pulmonary disease (COPD) and/or restrictive pulmonary diseases that affect the chest wall (e.g., neuromuscular disorders, kyphosis, scoliosis) and lungs, as evidenced by abnormal airflows and volumes
- Determine airway response to inhalants in patients with an airway-reactive disorder
- Determine the diffusing capacity of the lungs (DCOL)
- Determine the effectiveness of therapy regimens, such as bronchodilators, for pulmonary disorders
- Determine the presence of lung disease when other studies, such as x-rays, do not provide a definitive diagnosis, or determine the progression and severity of

known COPD and restrictive pulmonary disease

- Evaluate the cause of dyspnea occurring with or without exercise
- Evaluate lung compliance to determine changes in elasticity, as evidenced by changes in lung volumes (decreased in restrictive pulmonary disease, increased in COPD and in elderly patients)
- Evaluate pulmonary disability for legal or insurance claims
- Evaluate pulmonary function after surgical pneumonectomy, lobectomy, or segmental lobectomy
- Evaluate the respiratory system to determine the patient's ability to tolerate procedures such as surgery or diagnostic studies
- Screen high-risk populations for early detection of pulmonary conditions (e.g., patients with exposure to occupational or environmental hazards, smokers, patients with a hereditary predisposition)

RESULT:**Normal findings in:**

- Normal respiratory volume and capacities, gas diffusion, and distribution
- No evidence of COPD or restrictive pulmonary disease

Normal adult lung volumes, capacities, and flow rates are as follows:

TV	500 mL at rest
RV	1200 mL (approximate)
IRV	3000 mL (approximate)
ERV	1100 mL (approximate)
VC	4600 mL (approximate)
TLC	5800 mL (approximate)
IC	3500 mL (approximate)
FRC	2300 mL (approximate)
FVC	3000–5000 mL (approximate)
FEV ₁ /FVC	81%–83%
MMEF	25%–75%

(table continues on page 1016)

FIF	25%–75%
MVV	25%–35% or 170 L/min
PIFR	300 L/min
PEFR	450 L/min
F-V loop	Normal curve
DCOL	25 mL/min per mm Hg (approximate)
CV	10%–20% of VC
V _{iso}	Based on age formula
Bronchial provocation	No change, or less than 20% reduction in FEV ₁

Note: Normal values listed are estimated values for adults. Actual pediatric and adult values are based on age, height, and gender. These normal values are included on the patient's pulmonary function laboratory report.

TV = tidal volume; RV = residual volume; IRV = inspiratory reserve volume; ERV = expiratory reserve volume; VC = vital capacity; TLC = total lung capacity; IC = inspiratory capacity; FRC = functional residual capacity; FVC = forced vital capacity in 1 second; FEV₁ = forced expiratory volume in 1 second; MMEF = maximal midexpiratory flow (also known as FEF_{25–75}); FIF = forced inspiratory flow rate; MVV = maximal voluntary ventilation; PIFR = peak inspiratory flow rate; PEFR = peak expiratory flow rate; F-V loop = flow-volume loop; DCOL = diffusing capacity of the lungs; CV = closing volume; V_{iso} = isoflow volume.

Abnormal findings in:

- Allergy
- Asbestosis
- Asthma
- Bronchiectasis
- Chest trauma
- Chronic bronchitis
- Curvature of the spine
- Emphysema
- Myasthenia gravis
- Obesity
- Pulmonary fibrosis
- Pulmonary tumors
- Respiratory infections
- Sarcoidosis

- Confusion or inability to understand instructions or cooperate during the study can cause inaccurate results.
- Testing is contraindicated in patients with cardiac insufficiency, recent myocardial infarction, and presence of chest pain that affects inspiration or expiration ability.
- Exercise caution with patients who have upper respiratory infections, such as a cold or acute bronchitis.

CRITICAL VALUES: N/A

NURSING IMPLICATIONS AND PROCEDURE

INTERFERING FACTORS:

- The aging process can cause decreased values (FVC, DCOL) depending on the study done.
- Inability of the patient to put forth the necessary breathing effort affects the results.
- Medications such as bronchodilators can affect results.
- Improper placement of the nose clamp or mouthpiece that allows for leakage can affect volume results.

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses lung functions.
- ▶ Obtain a history of the patient's complaints or symptoms, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast mediums.
- ▶ Obtain a history of the patient's cardiovascular and respiratory systems,

symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no discomfort will be experienced during the test. Explain that the procedure is generally performed in a specially equipped room or in a health care provider's (HCP's) office by a HCP specializing in this procedure and usually lasts 1 hr.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Record the patient's height and weight.
- ▶ The patient should avoid bronchodilators (oral or inhaled) for at least 4 hr before the study, as directed by the HCP.
- ▶ Instruct the patient to refrain from smoking tobacco or eating a heavy meal for 4 to 6 hr prior to the study. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure the patient has complied with dietary and medication restrictions and pretesting preparations.
- ▶ Obtain an inhalant bronchodilator to treat any bronchospasms that may occur with testing.
- ▶ Instruct the patient to void and to loosen any restrictive clothing.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in a sitting position on a chair near the spirometry equipment.
- ▶ Place a soft clip on the patient's nose to restrict nose breathing, and instruct the patient to breathe through the mouth.
- ▶ Place a mouthpiece in the mouth and instruct the patient to close his or her lips around it to form a seal.
- ▶ Tubing from the mouthpiece is connected to a cylinder that is connected to a computer that measures, records, and calculates the values for the tests done.
- ▶ Instruct the patient to inhale deeply and then to quickly exhale as much air as possible into the mouthpiece.

- ▶ Additional breathing maneuvers are performed on inspiration and expiration (normal, forced, and breath-holding).

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Assess the patient for dizziness or weakness after the testing.
- ▶ Allow the patient to rest as long as needed to recover.
- ▶ Instruct the patient to resume usual diet and medications, as directed by the HCP.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy.

RELATED MONOGRAPHS:

- ▶ Related tests include α_1 -AT, anion gap, arterial/alveolar oxygen ratio, biopsy lung, blood gases, bronchoscopy, carboxyhemoglobin, chest x-ray, chloride sweat, complete blood count, complete blood count, WBC hemoglobin, complete blood count, WBC count and differential, CT angiography, CT thoracic, culture and smear for mycobacteria, culture bacterial sputum, culture viral, cytology sputum, echocardiography, ECG, gram stain, IgE, lactic acid, lung perfusion scan, lung ventilation scan, MR angiography, MRI chest, osmolality, phosphorus, plethysmography, pleural fluid analysis, potassium, PET chest, pulse oximetry, sodium, and TB skin test.
- ▶ Refer to the Cardiovascular and Respiratory Systems tables in the back of the book for related tests by body system.

Pulse Oximetry

SYNONYM/ACRONYM: Oximetry, Pulse Ox.

AREA OF APPLICATION: Earlobe, fingertip; for infants, use the large toe, top or bottom of the foot, or sides of the ankle.

CONTRAST: None.

DESCRIPTION: Pulse oximetry is a noninvasive study that provides continuous readings of arterial blood oxygen saturation (SPO₂) using a sensor site (earlobe or fingertip). The SPO₂ equals the ratio of the amount of O₂ contained in the hemoglobin to the maximum amount of O₂ contained with hemoglobin expressed as a percentage. The results obtained may compare favorably with O₂ saturation levels obtained by arterial blood gas analysis without the need to perform successive arterial punctures. The device used is a clip or probe that produces a light beam with two different wavelengths on one side. A sensor on the opposite side measures the absorption of each of the wavelengths of light to determine the O₂ saturation reading. The displayed result is a ratio, expressed as a percentage, between the actual O₂ content of the hemoglobin and the potential maximum O₂-carrying capacity of the hemoglobin.

INDICATIONS:

- Determine the effectiveness of pulmonary gas exchange function
- Evaluate suspected nocturnal hypoxemia in chronic obstructive pulmonary disease

- Monitor oxygenation during testing for sleep apnea
- Monitor oxygenation perioperatively and during acute illnesses
- Monitor oxygenation status in patients on a ventilator, during surgery, and during bronchoscopy
- Monitor O₂ saturation during activities such as pulmonary exercise stress testing or pulmonary rehabilitation exercises to determine optimal tolerance
- Monitor response to pulmonary drug regimens, especially flow and O₂ content

RESULT:

Normal findings in:

- Greater than or equal to 95%

Abnormal findings in:

- Abnormal gas exchange
- Hypoxemia with levels less than 95%
- Impaired cardiopulmonary function

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who smoke or have suffered carbon monoxide inhalation, because O₂ levels may be falsely elevated

Factors that may impair clear imaging:

- Patients with anemic conditions reflecting a reduction in

hemoglobin, the O₂-carrying component in the blood

- Excessive light surrounding the patient, such as from surgical lights
- Impaired cardiopulmonary function
- Lipid emulsion therapy and presence of certain dyes
- Movement of the finger or ear or improper placement of probe or clip
- Nail polish, false fingernails, and skin pigmentation when a finger probe is used
- Vasoconstriction from cool skin temperature, drugs, hypotension, or vessel obstruction causing a decrease in blood flow

Other considerations:

- Accuracy for most units is plus or minus 4% with a standard deviation of 1%.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient the procedure is used to monitor oxygenation of the blood.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ▶ Obtain a history of the patient's respiratory and cardiovascular systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the medications the patient is taking, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that no pain is associated with the procedure. Inform the patient that the procedure is generally performed

at the bedside, in the operating room during a surgical procedure, or in the office of a health care provider (HCP). Explain that the procedure lasts as long as the monitoring is needed and could be continuous.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ If a finger probe is used, instruct the patient to remove false fingernails and nail polish.
- ▶ When used in the presence of flammable gases, the equipment must be approved for that specific use.
- ▶ Instruct the patient not to smoke for 24 hr before the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with pretesting instructions.
- ▶ If a finger probe is used, instruct the patient not to grip treadmill rail or bed rail tightly; doing so restricts blood flow.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Massage or apply a warm towel to the upper earlobe or finger to increase the blood flow.
- ▶ The index finger is normally used, but if the patient's finger is too large for the probe, a smaller finger can be used.
- ▶ If the earlobe is used, make sure good contact is achieved.
- ▶ The big toe, top or bottom of the foot, or sides of the heel may be used in infants.
- ▶ Place the photodetector probe over the finger in such a way that the light beams and sensors are opposite each other. Turn the power switch to the oximeter monitor, which will display information about heart rate and peripheral capillary saturation (SaO₂).
- ▶ Remove the clip used for monitoring when the procedure is complete.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.

- ◆ Closely observe SPO₂, and report to the HCP if it decreases to 90%.
- ◆ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include α_1 -AT, anion gap, arterial/alveolar oxygen ratio, biopsy lung, blood gases, bronchoscopy, carboxyhemoglobin, chest x-ray, chloride sweat, complete blood count, complete blood count, hemoglobin, complete blood count, WBC count and differential, CT angiography, culture and smear for mycobacteria, culture bacterial sputum, culture viral, cytology sputum, ECG, gram stain, IgE, lactic acid, lung perfusion scan, lung ventilation scan, MR angiography, MR chest, osmolality, phosphorus, plethysmography, pleural fluid analysis, potassium, pulmonary function tests, sodium, and TB skin test.
- ◆ Refer to the Respiratory and Cardiovascular System tables in the back of the book for related tests by body system.

Pyruvate Kinase

SYNONYM/ACRONYM: PK.

SPECIMEN: Whole blood collected in yellow-top (acid-citrate-dextrose [ACD]) tube. Specimens collected in a lavender-top (EDTA) or green-top (heparin) tube also may be acceptable in some laboratories.

REFERENCE VALUE: (Method: Spectrophotometry) 9 to 22 international units/g hemoglobin.

RESULT:**Increased in:**

- Carriers of Duchenne's muscular dystrophy
- Muscle disease
- Myocardial infarction

Decreased in:

- Hereditary pyruvate kinase deficiency:
Congenital nonspherocytic hemolytic anemia

- Acquired pyruvate kinase deficiency:
Acute leukemia
Aplasias
Other anemias

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Radioactive Iodine Uptake

SYNONYM/ACRONYM: Thyroid uptake, RAIU.

AREA OF APPLICATION: Thyroid.

CONTRAST: Oral radioactive iodine.

DESCRIPTION: Radioactive iodine uptake (RAIU) is a nuclear medicine study used for evaluating thyroid function. It directly measures the ability of the thyroid gland to concentrate and retain circulating iodide for the synthesis of thyroid hormone. RAIU assists in the diagnosis of both hyperthyroidism and hypothyroidism, but it is more useful in the diagnosis of hyperthyroidism.

A very small dose of radioactive iodine-123 (I-123) or I-131 is administered orally and images are taken at specified intervals after the initial dose is administered. The radionuclide emits gamma radiation, which allows external measurement. The uptake of radionuclide in the thyroid gland is measured as the percentage of radionuclide absorbed in a specific amount of time. The iodide not used is excreted in the urine. The thyroid gland does not distinguish between radioactive and nonradioactive iodine. Uptake values are used in conjunction with measurements of circulating thyroid hormone levels to differentiate primary and secondary thyroid disease, and serial measurements are helpful in long-term management of thyroid disease and its treatment.

INDICATIONS:

- Evaluate hyperthyroidism and/or hypothyroidism
- Evaluate neck pain
- Evaluate the patient as part of a complete thyroid evaluation for symptomatic patients (e.g., swollen neck, neck pain, extreme sensitivity to heat or cold, jitters, sluggishness)
- Evaluate thyroiditis, goiter, or pituitary failure
- Monitor response to therapy for thyroid disease

RESULT:

Normal findings in:

- Variations in normal ranges of iodine uptake can occur with differences in dietary intake, geographic location, and protocols among laboratories:

Iodine Uptake	Percentage of Radionuclide
2-hr absorption	1%–13%
6-hr absorption	2%–25%
24-hr absorption	15%–45%

Abnormal findings in:

- Decreased iodine intake or increased iodine excretion
- Graves' disease
- Iodine-deficient goiter
- Hashimoto's thyroiditis (early)
- Hyperthyroidism, increased uptake of radionuclide:
Rebound thyroid hormone withdrawal
Drugs and hormones such as barbiturates, diuretics, estrogens, lithium carbonate, phenothiazines, and thyroid-stimulating hormone
- Decreased uptake:
Hypothyroidism, with a response of decreased uptake of 0 to 10% over a 24-hr period

- Hypoalbuminemia
- Malabsorption
- Renal failure
- Subacute thyroiditis
- Thyrotoxicosis as a result of ectopic thyroid metastasis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Recent use of iodinated contrast medium for radiographic studies (within the last 4 wk) or nuclear medicine procedures done within the previous 24 to 48 hr
- Iodine deficiency (e.g., patients with inadequate dietary intake, patients on phenothiazine therapy), which can increase radionuclide uptake
- Certain drugs and other external sources of excess iodine, which can decrease radionuclide uptake, as follows:

Foods containing iodine (e.g., iodized salt)

Drugs such as aminosalicic acid, antihistamines, antithyroid medications (e.g., propylthiouracil, iodothiouracil), corticosteroids, cough syrup, isoniazid, levothyroxine sodium/T₄, L-triiodothyronine, Lugol's solution, nitrates, penicillins, potassium iodide, propylthiouracil, saturated solution of potassium iodide, sulfonamides, thiocyanate, thyroid extract, tolbutamide, and warfarin

Multivitamins containing minerals

- Vomiting, severe diarrhea, and gastroenteritis, which can affect

absorption of the oral radionuclide dose

- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses thyroid function.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or dyes.
- ♦ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results, including examinations using iodine-based contrast medium.
- ♦ Ensure that this procedure is performed before all radiographic procedures using iodinated contrast medium.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Address concerns about pain related

to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a nuclear medicine department by a HCP who specializes in this procedure, with support staff, and takes approximately 15 to 30 min. Delayed images or data collection is needed 24 hr later.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ Instruct the patient to fast and restrict fluids for 8 to 12 hr before the procedure. The patient may eat 4 hr after the injection unless otherwise indicated. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluid, and medication restrictions for 8 to 12 hr before the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer the I-123 orally (pill form).
- ▶ Place the patient in a sitting or supine position in front of a radionuclide detector at 2, 6, and 24 hr after ingestion for uptake images.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ Advise patient to drink increased amounts of fluids for 24 hr to eliminate the radionuclide from the body, unless contraindicated. Tell the patient that radionuclide is eliminated from the body within 24 to 48 hr.

- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, albumin, ACE, antibodies antithyroglobulin, biopsy thyroid, BUN, CT spine, copper, creatinine, cystoscopy, fecal analysis, fecal fat, FSH, gastric emptying scan, GH, LH, PTH, protein, thyroglobulin, thyroid binding inhibitory immunoglobulins, thyroid scan, TSH, TSI, thyroxine, free T_4 , triiodothyronine, free T_3 , US thyroid, upper GI series, and UA.
- ▶ Refer to the Endocrine System table at the back of the book for tests by related body system.

Radiofrequency Ablation, Liver

SYNONYM/ACRONYM: RFA, RF ablation.

AREA OF APPLICATION: Liver.

CONTRAST: Done without contrast.

DESCRIPTION: One minimally invasive therapy to eliminate tumors in organs such as the liver is called radiofrequency ablation (RFA). This technique works by passing electrical current in the range of radiofrequency waves between the needle electrode and the grounding pads placed on the patient's skin. A special needle electrode is placed in the tumor under the guidance of an imaging method such as ultrasound, computed tomography (CT) scanning, or magnetic resonance imaging (MRI). A radiofrequency current is then passed through the electrode to heat the tumor tissue near the needle tip and to ablate, or eliminate, it. The current creates heat around the electrode inside the tumor, and this heat spreads out to destroy the entire tumor, but little of the surrounding normal liver tissue. The heat from radiofrequency energy also closes up small blood vessels, thereby minimizing the risk of bleeding. Because healthy liver tissue withstands more heat than a tumor, RFA is able to destroy a tumor and a small rim of normal tissue about its edges without affecting most of the normal liver. The dead tumor cells are gradually replaced by scar tissue that shrinks over time. Some liver tumors may have failed to respond to chemotherapy, or

have recurred after initial surgery, and may be treated by RFA. If there are multiple tumor nodules, they may be treated in one or more sessions. In general, RFA causes only minimal discomfort and may be done as an outpatient procedure without general anesthesia. RFA is most effective if the tumor or tumors are less than 2 in. in diameter; results are not as good when RFA is used to treat larger tumors. Similar therapy is being used to treat tumors in the kidney, pancreas, bone, thyroid, breast, adrenal gland, and lung.

INDICATIONS:

- Ablation of metastases to the liver
- Ablation of primary liver tumors, with hepatocellular carcinoma
- Therapy for multiple small liver tumors that are too spread out to remove surgically
- Therapy for recurrent liver tumors
- Therapy for tumors that are less than 2 in. in diameter
- Therapy for tumors that have failed to respond to chemotherapy
- Therapy for tumors that have recurred after initial surgery

Risks:

- May cause brief or long-lasting shoulder pain.
- May cause inflammation of the gallbladder.

- May cause damage to the bile ducts with resulting biliary obstruction.
- May cause thermal damage to the bowel.
- The patient may experience flu-like symptoms that appear 3 to 5 days after the procedure and last for approximately 5 days.
- The patient may experience bleeding. If bleeding is severe, surgery may be needed.

RESULT:

Normal findings in:

- Decrease in tumor size
- Normal size, position, contour, and texture of the liver

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with bleeding disorders
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, rings, surgery clips) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Failure to follow dietary restrictions and other pretesting preparations before the procedure may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety

concerns regarding younger patients or patients who are lactating.

- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron, stand behind a shield, or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses liver function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, and anesthetics.
- ▶ Obtain a history of the patient's hepatobiliary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including barium examinations.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the medications the patient is taking, including anticoagulant therapy, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that a sedative and/or analgesia will be administered to promote relaxation and

reduce discomfort prior to the needle electrode insertion. Explain to the patient that any discomfort with the needle electrode will be minimized with local anesthetics and systemic analgesics. Inform the patient that the procedure is performed in the radiology department by a HCP, with support staff, and takes approximately 30 to 90 min.

- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, or sedatives. Usually normal saline is infused.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ This procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions and pretesting preparations.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.

- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Place the patient in the supine position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ▶ A local anesthetic is injected at the site, and a needle electrode is inserted under ultrasound, CT, or MRI guidance.
- ▶ A radiofrequency current is passed through the needle electrode, and the tumor is ablated.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure. Monitor and administer an antiemetic agent if ordered. Ready an emesis basin for use.
- ▶ The needle electrode is removed, and a pressure dressing is applied over the puncture site.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and as ordered. Take temperature every 6 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Observe the needle electrode insertion site for bleeding, inflammation, or hematoma formation.

- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
- ▶ Advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Instruct the patient in the care and assessment of the site. Observe for bleeding, hematoma formation, bile leakage, and inflammation. Note any pleuritic pain, persistent right shoulder pain, or abdominal pain.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to physical activity. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography abdomen, AST, biopsy liver, CT liver, MRI abdomen, and US liver and biliary system.
- ▶ Refer to the Hepatobiliary System table at the back of the book for related tests by body system.

Radiography, Bone

SYNONYM/ACRONYM: Bone x-rays, hand x-rays, foot x-rays, wrist x-rays, arm x-rays.

AREA OF APPLICATION: Skeleton.

CONTRAST: None.

DESCRIPTION: Skeletal x-rays are used to evaluate extremity pain or discomfort due to trauma, bone abnormalities, or fluid within a joint. Serial skeletal x-rays are used to evaluate growth pattern. Radiation emitted from the x-ray machine passes through the patient onto a photographic plate or x-ray film. X-rays pass through air freely and are mostly absorbed

by the photographic media. Bones and tissues absorb the x-rays in varying degrees, thereby causing white and shades of gray on the x-ray recording media: Bones are very dense and therefore absorb most of the x-ray and appear white; organs are denser than air but not as dense as bone, so they appear in shades of gray. All metals absorb x-rays.

R

Because the x-ray is absorbed or blocked, metal appears totally white on the film and thus facilitates the search for foreign bodies in the patient.

INDICATIONS:

- Assist in detecting bone fracture, dislocation, deformity, and degeneration
- Evaluate for child abuse
- Evaluate growth pattern
- Identify abnormalities of bones, joints, and surrounding tissues
- Monitor fracture healing process

RESULT:

Normal findings in:

- *Infants and children:* Thin plate of cartilage, known as growth plate or epiphyseal plate, between the shaft and both ends
- *Adolescents and adults:* By age 17, calcification of cartilage plate; no evidence of fracture, congenital abnormalities, tumors, or infection

Abnormal findings in:

- Arthritis
- Bone degeneration
- Bone spurs
- Foreign bodies
- Fracture
- Genetic disturbance (achondroplasia, dysplasia, dyostosis)
- Hormonal disturbance
- Infection, including osteomyelitis
- Injury
- Joint dislocation or effusion
- Nutritional or metabolic disturbances
- Osteoporosis or osteopenia
- Soft-tissue abnormalities
- Tumor or neoplastic disease (osteogenic sarcoma, Paget's disease, myeloma)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field which may inhibit organ visualization and can produce unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the exam room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses bone structure of the area examined.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Explain that numerous x-rays may be taken depending on the bones or joint affected. Address concerns about pain and explain that some pain may be experienced during the test, or there may be moments of discomfort. Inform the patient that the procedure is performed in the radiology department by a HCP, with support staff, and takes approximately 10 to 30 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to inhale deeply and hold his or her breath while the image is taken. Warn the patient that the extremity's position during the procedure may be uncomfortable, but ask the patient to hold very still during the procedure because movement will produce unclear images.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
 - ▶ Have emergency equipment readily available.
 - ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
 - ▶ Place patient in a standing, sitting, or recumbent position in front of the image holder or electronic receiver.
 - ▶ Ask the patient to inhale deeply and hold his or her breath while the x-ray images are taken.
 - ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to the perceived loss of daily function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Explain the importance of adhering to the therapy regimen. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies anti-cyclic citrullinated peptide, ANA, arthrogram, arthroscopy, biopsy bone, BMD, bone scan, CRP, calcium, collagen cross-linked telopeptides, CT spine, ESR, MRI musculoskeletal, osteocalcin, phosphorus, synovial fluid analysis, RF, vitamin D, and WBC scan.
- ▶ Refer to the Musculoskeletal System table at the back of the book for related tests by body system.

Red Blood Cell Cholinesterase

SYNONYM/ACRONYM: acetylcholinesterase (AChE), erythrocyte cholinesterase, true cholinesterase.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Spectrophotometry, kinetic)

Test	Conventional Units
RBC cholinesterase	5300–10,000 international units/L

DESCRIPTION: There are two types of cholinesterase enzyme: *acetylcholinesterase (AChE)*, which is found in red blood cells (RBCs), lung, and brain (nerve) tissue; and *cholinesterase*, which is mainly found in the plasma, liver, and heart. RBC AChE is highly specific for acetylcholine. Cholinesterase has broader esterolytic activity and is referred to as “pseudocholinesterase.” Pseudocholinesterase is the test used to indicate succinylcholine sensitivity (see monograph titled “Pseudocholinesterase and Dibucaine Number”). RBC cholinesterase is used to assist in the diagnosis of chronic carbamate or organophosphate insecticide (e.g., parathion, malathion) toxicity. Organophosphate pesticides bind irreversibly with cholinesterase, inhibiting normal enzyme activity. Carbamate insecticides bind reversibly. Serum or plasma pseudocholinesterase is used more frequently to measure acute pesticide toxicity.

Patients with inherited cholinesterase deficiency are at risk during anesthesia if succinylcholine is administered as an

anesthetic. Succinylcholine, a short-acting muscle relaxant, is a reversible inhibitor of acetylcholinesterase and is hydrolyzed by cholinesterase. Succinylcholine-sensitive patients may be unable to metabolize the anesthetic quickly, resulting in prolonged or unrecoverable apnea. This test, along with the pseudocholinesterase test, is also used to identify individuals with atypical forms of the enzyme cholinesterase. The prevalence of succinylcholate sensitivity is 1 in 1500 patients. Widespread preoperative screening is not routinely performed.

INDICATIONS:

- Monitor cumulative exposure to organic phosphate insecticides
- Verify suspected exposure to organic phosphate insecticides

RESULT:

Increased in:

- Sickle cell anemia (**Increased in hemolytic anemias as it is released from the hemolyzed RBCs**)

Decreased in:

- Insecticide exposure (**Organic phosphate insecticides inhibit AChE activity**)
- Late pregnancy (**Related to anemia of pregnancy**)
- Paroxysmal nocturnal hemoglobinuria (**Related to lack of RBC production by bone marrow**)
- Relapse of megaloblastic anemia (**Related to underproduction of normal RBCs containing AChE**)

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs and substances that may increase RBC cholinesterase levels include echothiophate, parathion, and antiepileptic drugs such as carbamazepine, phenobarbital, phenytoin, and valproic acid.
- Improper anticoagulant; fluoride interferes with the measurement and causes a falsely decreased value.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- Inform the patient that the test is used to identify pesticide poisoning.
- Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex. Particularly important to report is exposure to pesticides causing symptoms including blurred vision, muscle weakness, nausea, vomiting, headaches, pulmonary edema, salivation, sweating, or convulsions.
- Obtain a history of exposure to occupational hazards and medication regimen.
- Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed

laboratory tests and diagnostic and surgical procedures.

- Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a

change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

▶ Related tests include biopsy bone marrow, complete blood count,

complete blood count, RBC indices, complete blood count, RBC morphology, Ham's test, pseudocholinesterase, sickle cell screen, and vitamin B₁₂.

▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Refraction

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: This noninvasive procedure tests the visual acuity (VA) of the eyes and determines abnormalities or refractive errors that need correction. Refractions are performed using a combination of different pieces of equipment. Refractive error can be quickly and accurately measured using computerized automatic refractors or manually with a viewing system consisting of an entire set of trial lenses mounted on a circular wheel (phoropter). A projector may also be used to display test letters and characters for use in assessing VA. If the VA is less than 20/20 the pinhole test may be used to quickly assess the best corrected vision. Refractive errors of the peripheral cornea and lens can be reduced or eliminated by having the patient look through a pinhole at the vision test. Patients with cataracts or visual field defects

will not show improved results using the pinhole test. The retinoscope is probably the most valuable instrument that can be used to objectively assess VA. It is also the only objective means of assessing refractive error in pediatric patients and patients who are unable to cooperate with other techniques of assessing refractive error due to illiteracy, senility, or inability to speak the same language as the examiner. Visual defects identified through refraction, such as hyperopia (farsightedness), in which the point of focus lies behind the retina; myopia (nearsightedness), in which the point of focus lies in front of the retina; and astigmatism, in which the refraction is unequal in different curvatures of the eyeball, can be corrected by glasses, contact lenses, or refractive surgery.

INDICATIONS:

- Determine if an optical defect is present and if light rays entering the eye focus correctly on the retina
- Determine the refractive error prior to refractive surgery—e.g., radial keratotomy (RK), photorefractive keratotomy (PRK), laser assisted in situ keratomileusis (LASIK), intra-corneal rings (Intacs), limbal relaxing incisions (LRI), implantable contact lens (phakic IOL), clear lens replacement—being performed
- Determine the type of corrective lenses needed for refractive errors, for example, biconvex or plus lenses for hyperopia, biconcave or minus lenses for myopia, compensatory lenses for astigmatism
- Diagnose refractive errors in vision

RESULT:**Visual Acuity Scale**

Foot	Meter	Decimal
20/200	6/60	0.1
20/160	6/48	0.13
20/120	6/36	0.17
20/100	6/30	0.2
20/80	6/24	0.25
20/60	6/18	0.33
20/50	6/15	0.4
20/40	6/12	0.5
20/30	6/9	0.63
20/25	6/7.5	0.8
20/20	6/6	1
20/16	6/4.8	1.25
20/12	6/3.6	1.67
20/10	6/3	2

VA can be expressed fractionally in feet, fractionally in meters, or as a decimal where perfect vision of 20/20 feet or 6/6 meters is equal to 1. A patient who cannot achieve best corrected VA of 20/200 or above in his or her better eye is considered legally blind in the U.S. Comparing the fraction in feet or meters to the decimal helps demonstrate that “less than” 20/20 is “worse” vision while acuity “greater than” 20/20 is “better”.

Normal findings in:

- Normal visual acuity; greater than 20/30 (with corrective lenses if appropriate).

Abnormal findings in:

- Corrected visual acuity of 20/40 or less
- Refractive errors such as astigmatism, hyperopia, and myopia.

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

- Patients with narrow-angle glaucoma if pupil dilation is performed, as dilation can initiate a severe and sight-threatening open-angle attack.
- Patients with allergies to mydriatics if pupil dilation using mydriatics is performed.

Factors that may impair clear imaging:

- Improper pupil dilation may prevent adequate examination for refractive error.
- Inability of the patient to cooperate and remain still during the procedure because of age, significant pain, or mental status may interfere with the test results.
- Failure to follow medication restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

R

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure evaluates visual acuity.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially mydriatics if dilation is to be performed.

- ▶ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that mydriatics, if used, may cause blurred vision and sensitivity to light. There may also be a brief stinging sensation when the drop is put in the eye. Inform the patient that a health care provider (HCP) performs the test, in a quiet, darkened room, and that to evaluate both eyes, the test can take up 30 min (including time for the pupils to dilate before the test is actually performed).
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction.
- ▶ The patient should withhold eye medications (particularly mydriatic eye drops if the patient has glaucoma) for at least 1 day prior to the test.
- ▶ Ensure that the patient understands that he or she must refrain from driving until the pupils return to normal (about 4 hours) after the test and has made arrangements to have someone else be responsible for transportation after the test.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions and pretesting preparations; assure that eye medications, especially mydriatics,

- have been restricted for at least 1 day prior to the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ▶ If dilation is to be performed, administer the ordered mydriatic to each eye and repeat in 5 to 15 min. Drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semi-transparent area of the eyeball where the cornea and sclera meet). The dropper bottle should not touch the eyelashes.
- ▶ Ask the patient to place the chin in the chin rest and gently press the forehead against the support bar. The examiner will sit about 2 ft away at eye level with the patient. The retinoscope light is held in front of the eyes and directed through the pupil. Each eye is also examined for the characteristics of the red reflex, the reflection of the light from the retinoscope, which normally moves in the same direction as the light.
- ▶ Request that the patient look straight ahead while the eyes are examined with the instrument and while different lenses are tried to provide the best corrective lenses to be prescribed. When optimal VA is obtained with the trial lenses in each eye, a prescription for corrective lenses is written.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications, as directed by the HCP.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to vision loss, anticipated loss of driving privileges, or the possibility of requiring corrective lenses (self-image). Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide contact information, if desired, for a general patient education web

site on the topic of eye care (e.g., www.allaboutvision.com).

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that visual acuity and responses to light may change. Suggest that the patient wear dark glasses after the test until the pupils return to normal size. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be

performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include color perception test, intraocular muscle function, intraocular pressure, Schirmer tear test, and slit-lamp biomicroscopy.
- ◆ Refer to the Ocular System table at the back of the book for related tests by body system.

Renin

SYNONYM/ACRONYM: Plasma renin activity (PRA).

SPECIMEN: Plasma (3 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Radioimmunoassay)

Age and Position	Conventional Units	SI Units (Conventional Units × 1)
Newborn	2.0–35.0 ng/mL/hr	2.0–35.0 mcg/L/hr
Supine, normal sodium diet		
1–12 mo	2.4–37.0 ng/mL/hr	2.4–37.0 mcg/L/hr
1–3 yr	1.7–112 ng/mL/hr	1.7–112 mcg/L/hr
3–5 yr	1.0–6.5 ng/mL/hr	1.0–6.5 mcg/L/hr
5–10 yr	0.5–5.9 ng/mL/hr	0.5–5.9 mcg/L/hr
10–15 y	0.5–3.3 ng/mL/hr	0.5–3.3 mcg/L/hr
Adult	0.2–1.6 ng/mL/hr	0.2–1.6 mcg/L/hr
Upright, normal sodium diet		
Adult	0.7–3.3 ng/mL/hr	0.7–3.3 mcg/L/hr

Values vary according to the laboratory performing the test, as well as the patient's age, gender, dietary pattern, state of hydration, posture, and physical activity.

DESCRIPTION: Renin is an enzyme that activates the renin-angiotensin system. It is released into the renal veins by the juxtaglomerular apparatus in response to sodium depletion and hypov-

olemia. Renin converts angiotensinogen to angiotensin I. Angiotensin I is converted to angiotensin II, the biologically active form. Angiotensin II is a powerful vasoconstrictor that

stimulates aldosterone production in the adrenal cortex. Angiotensin II and aldosterone increase blood pressure. Excessive amounts of angiotensin II cause renal hypertension. The renin assay screens for essential, renal, or renovascular hypertension. Plasma renin is expressed as the rate of angiotensin I formation per unit of time. The random collection of specimens without prior dietary preparations does not provide clinically significant information. Values should also be evaluated along with simultaneously collected aldosterone levels (see monographs titled “Aldosterone” and “Angiotensin-Converting Enzyme”).

INDICATIONS:

- Assist in the identification of primary hyperaldosteronism resulting from aldosterone-secreting adrenal adenoma
- Assist in monitoring patients on mineralocorticoid therapy
- Assist in the screening of the origin of essential, renal, or renovascular hypertension

RESULT:

Increased in:

- Addison's disease (*Related to hyponatremia, which stimulates production of renin*)
- Bartter's syndrome (*Hereditary defect in Loop of Henle that affects sodium resorption; hyponatremia stimulates renin production*)
- Cirrhosis (*Fluid buildup dilutes sodium concentration; hyponatremia is a strong stimulus for production of renin*)
- Congestive heart failure (*Fluid buildup dilutes sodium concentration; hyponatremia is a*

strong stimulus for production of renin)

- Gastrointestinal disorders with electrolyte loss (*Hyponatremia stimulates production of renin*)
- Hepatitis (*Fluid buildup dilutes sodium concentration; hyponatremia is a strong stimulus for production of renin*)
- Hypokalemia (*Decreased potassium levels stimulate renin production*)
- Malignant hypertension (*Related to secondary hyperaldosteronism that constricts the blood vessels and results in hypertension*)
- Nephritis (*The kidneys can produce renin in response to inflammation or disease*)
- Nephropathies with sodium and potassium wasting (*Hyponatremia stimulates production of renin*)
- Pheochromocytoma (*Related to renin production in response to hypertension*)
- Pregnancy (*Related to retention of fluid and hyponatremia that stimulates renin production; normal pregnancy is associated with changes in the balance between renin and angiotensin*)
- Renin-producing renal tumors
- Renovascular hypertension (*Decreased renal blood flow stimulates release of renin*)

Decreased in:

- Cushing's syndrome (*Excessive production of glucocorticoids increase sodium levels and decrease potassium levels, which inhibits renin production*)
- Primary hyperaldosteronism (*Aldosterone secreting adrenal tumor; aldosterone inhibits renin production*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase renin levels include albuterol, amiloride, azosemide, benazepril,

- bendroflumethiazide, captopril, chlorthalidone, cilazapril, cromakalim, desmopressin, diazoxide, dihydralazine, doxazosin, enalapril, endralazine, felodipine, fenoldopam, fosinopril, furosemide, hydralazine, hydrochlorothiazide, laxatives, lisinopril, lithium, methylothiazide, metolazone, muzolimine, nicardipine, nifedipine, opiates, oral contraceptives, perindopril, ramipril, spironolactone, triamterene, and xipamide.
- Drugs and substances that may decrease renin levels include acetylsalicylic acid, angiotensin, angiotensin II, atenolol, bopindolol, bucindolol, carbenoxolone, carvedilol, clonidine, cyclosporin A, dexfenfluramine, glycyrrhiza, ibuprofen, indomethacin, levodopa, metoprolol, naproxen, nicardipine, nonsteroidal anti-inflammatory drugs, oral contraceptives, oxprenolol, propranolol, sulindac, and vasopressin.
 - Upright body posture, stress, and strenuous exercise can increase renin levels.
 - Recent radioactive scans or radiation can interfere with test results when radioimmunoassay is the test method.
 - Diet can significantly affect results (e.g., low-sodium diets stimulate the release of renin).
 - Hyperkalemia, acute increase in blood pressure, and increased blood volume may suppress renin secretion.
 - Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to evaluate hypertension.
- ▶ Obtain a history of the patient's complaints, including a list of known allergies, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient or family member that the position required (supine or upright) must be maintained for 2 hr before specimen collection. Inform the patient that multiple specimens may be required. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ The patient should be on a normal sodium diet (1 to 2 g sodium per day) for 2 to 4 wk before the test. Protocols may vary from facility to facility.
- ▶ By medical direction, the patient should avoid diuretics, antihypertensive drugs, herbals, cyclic progestogens, and estrogens for 2 to 4 wk before the test.
- ▶ Prepare an ice slurry in a cup or plastic bag to have ready for immediate transport of the specimen to the laboratory.

INTRATEST:

- ▶ Ensure that the patient has complied with diet and medication restrictions and pretesting dietary preparations; assure that specific medications have been restricted for at least 2 to 4 wk prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Specify patient position (upright or supine) and exact source of specimen (peripheral vs. arterial). Perform a venipuncture after the patient has been in the upright (sitting or standing) position for 2 hr. If a supine specimen is requested on an inpatient, the specimen should be collected early in the morning before the patient rises.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ The sample should be placed in an ice slurry immediately after collection. Information on the specimen label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag. Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual medications, as directed by the HCP.
- ▶ **Nutritional considerations:** Instruct the patient to notify the requesting HCP of any signs and symptoms of dehydration or fluid overload related to abnormal renin levels or compromised sodium regulatory mechanisms. Fluid loss or dehydration is signaled by the thirst response. Decreased skin turgor, dry mouth, and multiple longitudinal furrows in the tongue are symptoms of dehydration. Fluid overload may be signaled by a loss of appetite and nausea. Excessive fluid also causes pitting edema: When firm pressure is placed on the skin over a bone (e.g., the ankle), the indentation will remain after 5 sec.
- ▶ **Nutritional considerations:** Educate patients of the importance of proper water balance. There is no recommended daily allowance (RDA) for water. Adults need 1 mL/kcal per day; infants need more because their basal metabolic heat production is much higher. In buildings with hard water, untreated tap water contains minerals such as calcium, magnesium, and iron. Water-softening systems replace these minerals with sodium, and therefore patients on a low-sodium diet should avoid drinking treated tap water and drink bottled water instead.
- ▶ **Nutritional considerations:** Renin levels affect the regulation of fluid balance and electrolytes. If appropriate, educate patients with low sodium levels that the major source of dietary sodium is found in table salt. Many foods, such as milk and other dairy products, are also good sources of dietary sodium. Most other dietary sodium is available through the consumption of processed foods. Patients on low-sodium diets should be advised to avoid beverages such as colas, ginger ale, sports drinks, lemon-lime sodas, and root beer. Many over-the-counter medications, including antacids, laxatives, analgesics, sedatives, and antitussives, contain significant amounts of sodium. The best advice is to emphasize the importance of reading all food, beverage, and medicine labels. In 1989, the Subcommittee on the 10th Edition of the RDA established 500 mg/d as the recommended maximum daily intake for dietary intake of sodium. The requesting HCP or nutritionist should be consulted before the patient on a low-sodium diet begins using salt substitutes. There are no RDAs established for potassium, but the estimated minimum intake for adults is 200 mEq/d. Potassium is present in all plant and animal cells, making dietary replacement fairly simple to achieve.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation

to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

▶ Related tests include ACTH, ALT, aldosterone, ACE, AST, ANP, BNP, bilirubin, biopsy kidney, BUN, calcium, chloride, cortisol, creatinine, DHEAS,

fecal fat, GGT, glucose, GTT, magnesium, metanephrines, potassium, protein total and fractions, renogram, sodium, UA, and VMA.

▶ Refer to the Endocrine and Genitourinary System tables at the back of the book for related tests by body system.

Renogram

SYNONYM/ACRONYM: Renocystography, renocystogram, radioactive renogram, renal scintigraphy.

AREA OF APPLICATION: Kidneys.

CONTRAST: IV radioactive material.

DESCRIPTION: A renogram is a nuclear medicine study performed to assist in diagnosing renal disorders, such as abnormal blood flow, collecting-system defects, and excretion dysfunction. Because renography uses no iodinated contrast medium, it is safe to use in patients who have iodine allergies or compromised renal function.

After IV administration of the radioisotope, information about the structures of the kidneys is obtained. The radioactive material is detected by a gamma camera, which can detect the gamma rays emitted by the radionuclide in the kidney. Renography simultaneously tracks the rate at which the radionuclide flows into (*vascular phase*), through (*tubular phase*), and out of (*excretory phase*) the kidneys. The times are plotted on a graph and compared to normal parameters of organ function.

Differential estimates of left and right kidney contributions to glomerular filtration rate and effective renal plasma flow can be calculated. With the use of diuretic stimulation during the excretory phase, it is possible to differentiate between anatomic obstruction and nonobstructive residual dilation from previous hydronephrosis. All information obtained is stored in a computer to be used for further interpretation and computations. Renal function can be monitored by serially repeating this test and comparing results.

INDICATIONS:

- Aid in the diagnosis of renal artery embolism or renal infarction causing obstruction
- Aid in the diagnosis of renal artery stenosis resulting from renal dysplasia or atherosclerosis and

causing arterial hypertension and reduced glomerular filtration rate

- Aid in the diagnosis of renal vein thrombosis resulting from dehydration in infants or obstruction of blood flow in the presence of renal tumors in adults
- Detect renal infectious or inflammatory diseases, such as acute or chronic pyelonephritis, renal abscess, or nephritis
- Determine the presence and effects of renal trauma, such as arterial injury, renal contusion, hematoma, rupture, arteriovenous fistula, or urinary extravasation
- Determine the presence, location, and cause of obstructive uropathy, such as calculi, neoplasm, congenital disorders, scarring, or inflammation
- Evaluate acute and chronic renal failure
- Evaluate chronic urinary tract infections, especially in children
- Evaluate kidney transplant for acute or chronic rejection
- Evaluate obstruction caused by stones or tumor

RESULT:

Normal findings in:

- Normal shape, size, position, symmetry, vasculature, perfusion, and function of the kidneys
- Radionuclide material circulates bilaterally, symmetrically, and without interruption through the renal parenchyma, ureters, and urinary bladder, with 50% of the radionuclide excreted within the first 10 min

Abnormal findings in:

- Acute tubular necrosis
- Congenital anomalies (e.g., absence of a kidney)
- Decreased renal function
- Diminished blood supply
- Infection or inflammation (pyelonephritis, glomerulonephritis)
- Masses
- Obstructive uropathy

- Renal failure, infarction, cyst, or abscess
- Renal vascular disease, including renal artery stenosis or renal vein thrombosis
- Trauma

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Serum creatinine levels greater than or equal to 3 mg/dL (depending on the radionuclide used), which can decrease renal perfusion
- Other nuclear medicine studies done within the previous 24 to 48 hr
- Medications such as antihypertensives, angiotensin-converting enzyme (ACE) inhibitors, and β -blockers taken within 24 hr of the test
- Dehydration, which can accentuate abnormalities; or overhydration, which can mask abnormalities
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from

frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

- Inaccurate timing of imaging after the radionuclide injection can affect the results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the renal system.
- ▶ Obtain a history of the patient's complaints, including a list of known allergies, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort. Reassure the patient that radioactive material poses minimal radioactive hazard because of its short half-life and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department by a HCP and usually takes approximately 60 to 90 min, and that delayed images are needed 2 to 24 hr later. The patient may leave the department and return later to undergo delayed imaging.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Inform the patient that he or she will be asked to drink several glasses of fluid before the study for hydration, unless the patient has a restricted fluid intake for other reasons.
- ▶ There are no food or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place the patient in a supine position on a flat table with foam wedges to help maintain position and immobilization.
- ▶ The radionuclide is administered IV, and the kidney area is scanned immediately with images taken every minute for 30 min.
- ▶ During the flow and static imaging, the diuretic furosemide (Lasix) or ACE inhibitor (captopril) can be administered IV and images obtained.
- ▶ Urine and blood laboratory studies are done after the renogram to correlate findings before diagnosis.
- ▶ If a study for vesicoureteral reflux is done, the patient is asked to void, and a catheter is inserted into the bladder. The radionuclide is instilled into the bladder, and multiple images are obtained during bladder filling. The patient is then requested to void, with the catheter in place or after catheter removal, depending on department policy. Imaging is continued during and after voiding. Reflux is determined by

calculating the urine volume and counts obtained by imaging.

- ◆ Gloves should be worn during the radionuclide administration and while handling the patient's urine.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ◆ Instruct the patient to immediately flush the toilet and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ◆ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash ungloved hands after the gloves are removed.
- ◆ Observe the needle site for bleeding, hematoma formation, and inflammation. Instruct the patient in the care and assessment of the injection site.
- ◆ Recognize anxiety related to test results. Discuss the implications of

abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical importance of the test results, as appropriate.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include angiography renal, antibodies anti-glomerular basement membrane, biopsy kidney, bladder cancer markers, BUN, calculus kidney stone panel, C4, CT abdomen, CT pelvis, CT renal, creatinine, creatinine clearance, cystoscopy, IVP, KUB studies, MRA, MRI abdomen, retrograde ureteropyelography, strep group A, US kidney, and UA.
- ◆ Refer to the Genitourinary System table at the back of the book for related tests by body system.

Reticulocyte Count

SYNONYM/ACRONYM: Retic count.

SPECIMEN: Whole blood (1 mL) collected in lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Microscopic examination of specially stained peripheral blood smear or automated analyzer)

Age	Total Erythrocyte Count*
Newborn	3%–7%
1–12 mo	0.2%–2.8%
Adult	1.5%–2.5%

*Values are expressed as percentage of the red blood cell count.

DESCRIPTION: Normally, as it matures, the red blood cell (RBC) loses its nucleus. The remaining ribonucleic acid (RNA) will produce a characteristic color when special stains are used, making these cells easy to identify and enumerate. The presence of reticulocytes is an indication of the level of erythropoietic activity in the bone marrow. In abnormal conditions, reticulocytes are prematurely released into circulation. (See monographs titled “Complete Blood Count, RBC Count” and “Complete Blood Count, RBC Morphology and Inclusions.”)

INDICATIONS:

- Evaluate erythropoietic activity
- Monitor response to therapy for anemias

RESULT:

The reticulocyte production index (RPI) is a good estimate of RBC production. The calculation corrects the count for anemia and for the premature release of reticulocytes into the peripheral blood during periods of hemolysis or significant bleeding. The RPI also takes the maturation time of large polychromatophilic cells or nucleated RBCs seen on the peripheral smear into consideration:

$$\text{RPI} = \% \text{ reticulocytes} \times \left[\frac{\text{patient hematocrit (Hct)}}{\text{normal Hct}} \right] \times \left(\frac{1}{\text{maturation time}} \right)$$

As the formula shows, the RPI is inversely proportional to Hct, as follows:

Hematocrit (%)	Maturation Time (days)
45	1.0
35	1.5
25	2.0
15	2.5

Increased in:

Conditions that result in excessive RBC loss or destruction stimulate a compensatory bone marrow response by increasing production of rbcs.

- Blood loss
- Hemolytic anemias
- Iron-deficiency anemia
- Megaloblastic anemia

Decreased in:

- Alcoholism (**Decreased production related to nutritional deficit**)
- Anemia of chronic disease
- Aplastic anemia (**Related to overall lack of RBC**)
- Bone marrow replacement (**New marrow fails to produce rbcs until it engrafts**)
- Endocrine disease (**Hypometabolism related to hypothyroidism is reflected by decreased bone marrow activity**)
- RBC aplasia (**Related to overall lack of RBC**)
- Renal disease (**Diseased kidneys cannot produce erythropoietin which stimulates the bone marrow to produce rbcs**)
- Sideroblastic anemia (**Rbcs are produced but are abnormal in that they cannot incorporate iron into hemoglobin, resulting in anemia**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase reticulocyte counts include acetanilid, acetylsalicylic acid, amyl nitrate, antimalarials, antipyretics, antipyrine, arsenicals, corticotropin, dimercaprol, furaltadone, furazolidone, levodopa, methylodopa, nitrofurans, penicillin, procainamide, and sulfones.
- Drugs that may decrease reticulocyte counts include azathioprine, dactinomycin, hydroxyurea, methotrexate, and zidovudine.

- Reticulocyte count may be falsely increased by the presence of RBC inclusions (Howell-Jolly bodies, Heinz bodies, and Pappenheimer bodies) that stain with methylene blue.
- Reticulocyte count may be falsely decreased after a recent blood transfusion, as a result of the dilutional effect.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess erythropoietic activity and monitor antianemic therapy.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, complement, complete blood count, complete blood count, hematocrit, complete blood count, hemoglobin, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology, Coomb's antiglobulin direct and indirect, erythropoietin, iron/TIBC, ferritin, folate, G6PD, Ham's test, Hgb electrophoresis, lead, osmotic fragility, PK, sickle cell screen, and vitamin B₁₂.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Retrograde Ureteropyelography

SYNONYM/ACRONYM: Retrograde.

AREA OF APPLICATION: Renal calyces, ureter.

CONTRAST: Radiopaque iodine-based contrast medium.

DESCRIPTION: Retrograde ureteropyelography uses a contrast medium introduced through a ureteral catheter during cystography and radiographic visualization to view the renal collecting system (calyces, renal pelvis, and urethra). During a cystoscopic examination, a catheter is advanced through the ureters and into the kidney; contrast medium is injected through the catheter into the kidney. This procedure is primarily used in patients who are known to be hypersensitive to IV injected iodine-based contrast medium and when excretory ureterography does not adequately reveal the renal collecting system. The incidence of allergic reaction to the contrast medium is reduced because there is less systemic absorption of the contrast medium when injected into the kidney than when injected IV. Retrograde ureteropyelography sometimes provides more information about the anatomy of the different parts of the collecting system than can be obtained by excretory ureteropyelography. The procedure is not hampered by impaired renal function, but it carries the risk of urinary tract infection and sepsis.

INDICATIONS:

- Evaluate the effects of urinary system trauma
- Evaluate known or suspected ureteral obstruction
- Evaluate placement of a ureteral stent or catheter
- Evaluate the presence of calculi in the kidneys, ureters, or bladder
- Evaluate the renal collecting system when excretory urography is unsuccessful
- Evaluate space-occupying lesions or congenital anomalies of the urinary system
- Evaluate the structure and integrity of the renal collecting system

RESULT:

Normal findings in:

- Normal outline and opacification of renal pelvis and calyces
- Normal size and uniform filling of the ureters
- Symmetrical and bilateral outline of structures

Abnormal findings in:

- Congenital renal or urinary tract abnormalities
- Hydronephrosis
- Neoplasms
- Obstruction as a result of tumor, blood clot, stricture, or calculi
- Obstruction of ureteropelvic junction
- Perinephric abscess
- Perinephric inflammation or suppuration
- Polycystic kidney disease

- Prostatic enlargement
- Tumor of the kidneys or the collecting system

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
- Patients who are in renal failure.
- Patients with renal insufficiency, indicated by a blood urea nitrogen value greater than 40 mg/dL, because contrast medium can complicate kidney function.
- Young patients (17 y.o. and younger), unless the benefits of the x-ray diagnosis outweigh the risks of exposure to high levels of radiation.
- Patients with multiple myeloma, who may experience decreased kidney function subsequent to administration of contrast medium.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the

examination field, which may inhibit organ visualization and cause unclear images

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses the renal collecting system.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ♦ Obtain a history of the patient's genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results, including examinations using barium.

- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, or there may be moments of discomfort. Inform the patient that the procedure is performed in a special department, usually in a radiology or vascular suite, by a HCP, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Inform the patient that he or she may receive a laxative the night before the test and an enema or a cathartic the morning of the test, as ordered.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives. Usually normal saline is infused.
- ▶ Inform the patient that if a local anesthetic is used, the patient may feel (1) some pressure in the kidney area as the catheter is introduced and contrast medium injected, and (2) the urgency to void.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.

- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Place patient supine on the table in the lithotomy position.
- ▶ A kidney, ureter, and bladder (KUB) or plain image is taken to ensure that no barium or stool will obscure visualization of the urinary system. The patient may be asked to hold his or her breathe to facilitate visualization.
- ▶ The patient is given a local anesthetic, and a cystoscopic examination is performed and the bladder is inspected.

- ▶ A catheter is inserted, and the renal pelvis is emptied by gravity. Contrast medium is introduced into the catheter. Inform the patient that the contrast medium may cause a temporary flushing of the face, a feeling of warmth, or nausea.
- ▶ X-ray images are made and the results processed. Inform the patient that additional images may be necessary to visualize the area in question.
- ▶ Additional contrast medium is injected through the catheter to outline the ureters as the catheter is withdrawn.
- ▶ The catheter may be kept in place and attached to a gravity drainage unit until urinary flow has returned or is corrected.
- ▶ Additional x-ray images are taken 10 to 15 min after the catheter is removed to evaluate retention of the contrast medium, indicating urinary stasis.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
 - ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP. Renal function should be assessed before metformin is resumed.
 - ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
 - ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
 - ▶ Advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
 - ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
 - ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Monitor for signs of sepsis and severe pain in the kidney area.
 - ▶ Maintain the patient on adequate hydration after the procedure. Encourage the patient to drink lots of fluids to prevent stasis and to prevent the buildup of bacteria.
 - ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
 - ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
 - ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography renal, BUN, calculus kidney stone panel, CT abdomen, creatinine, cystoscopy, KUB, IVP, MRI abdomen, PT/INR, PSA, renogram, US kidney, urinalysis, and voiding cystourethrography.
- ▶ Refer to the Genitourinary System table at the back of the book for related tests by body system.

Rheumatoid Factor

SYNONYM/ACRONYM: RF, RA.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Nephelometry) 0 to 20 international units/mL.

DESCRIPTION: Individuals with rheumatoid arthritis harbor a macroglobulin-type antibody called *rheumatoid factor (RF)* in their blood. Patients with other diseases (e.g., systemic lupus erythematosus [SLE] and occasionally tuberculosis, chronic hepatitis, infectious mononucleosis, and subacute bacterial endocarditis) may also test positive for RF. RF antibodies are usually immunoglobulin (Ig) M but may also be IgG or IgA.

INDICATIONS:

Assist in the diagnosis of rheumatoid arthritis, especially when clinical diagnosis is difficult

RESULT:

Increased in:

Pathophysiology is unclear but RF is present in numerous conditions including rheumatoid arthritis.

- Chronic hepatitis
- Chronic viral infections
- Cirrhosis
- Dermatomyositis
- Infectious mononucleosis
- Leishmaniasis
- Leprosy
- Malaria
- Rheumatoid arthritis
- Sarcoidosis
- Scleroderma
- Sjögren's syndrome
- SLE

- Syphilis
- Tuberculosis
- Waldenström's macroglobulinemia

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Older patients may have higher values.
- Recent blood transfusion, multiple vaccinations or transfusions, or an inadequately activated complement may affect results.
- Serum with cryoglobulin or high lipid levels may cause a false-positive test and may require that the test be repeated after a fat-restriction diet.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the differential diagnosis and prognosis of arthritic diseases.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of impaired

- activity related to anticipated chronic pain resulting from joint inflammation, impairment in mobility, musculoskeletal deformity, and loss of independence. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services, as appropriate. Provide contact information, if desired, for the Arthritis Foundation (www.arthritis.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Advise the patient, as appropriate, that additional studies may be undertaken to determine treatment regimen or to determine the possible causes of symptoms if the test is negative for rheumatoid arthritis. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related laboratory tests include antibodies anti-cyclic citrullinated peptide, ANA, arthrogram, arthroscopy, biopsy bone, BMD, bone scan, CRP, calcium, collagen cross-linked telopeptides, CT spine, ESR, MRI musculoskeletal, osteocalcin, phosphorus, radiography bone, synovial fluid analysis, uric acid, vitamin D, and WBC scan.
- ▶ Refer to the Immune and Musculoskeletal System tables at the back of the book for related tests by body system.

Rubella Antibodies

SYNONYM/ACRONYM: German measles serology.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect immunofluorescence) Immune or less than a fourfold increase in titer.

DESCRIPTION: Rubella, commonly known as German measles, is a communicable viral disease transmitted by contact with respiratory secretions and aerosolized droplets of the secretions. The incubation period is 14 to 21 days. This disease produces a pink, macular rash that disappears in 2 to 3 days. Rubella infection induces immunoglobulin (Ig) G and IgM antibody production. This test can determine current infection or immunity from past infection. Rubella serology is part of the TORCH (toxoplasmosis, rubella, cytomegalovirus, and herpes simplex type 2) panel routinely performed on pregnant women. Fetal infection during the first trimester can cause spontaneous abortion or congenital defects. Ideally the immune status of women of childbearing age should be ascertained before pregnancy, when vaccination can be administered to provide lifelong immunity. The presence of IgM antibodies indicates acute infection. The presence of IgG antibodies indicates current or past infection. Susceptibility to rubella is indicated by a negative reaction. Many laboratories use a qualitative assay that detects the presence of both IgM and IgG rubella antibodies. IgM- and IgG-specific enzyme immunoassays are also available

to help distinguish acute infection from immune status. A rise in titer greater than fourfold in paired specimens is an indication of current infection.

INDICATIONS:

- Assist in the diagnosis of rubella infection
- Determine presence of rubella antibodies
- Determine susceptibility to rubella, particularly in pregnant women
- Perform as part of routine prenatal serological testing

RESULT:

Positive findings in:

- **Rubella infection (past or present)**

CRITICAL VALUES:

Note and immediately report to the health care provider (HCP) patients with a rubella-nonimmune status.

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the test is used to identify rubella infection or immunity.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of exposure to rubella.
- ▶ Obtain a history of the patient's immune and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that several tests may be necessary to confirm diagnosis. Any individual positive result should be repeated in 7 to 14 days to monitor a change in titer. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain to the patient that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Vaccination considerations:** Record the date of the last menstrual period and determine the possibility of pregnancy prior to administration of rubella vaccine to female rubella-nonimmune patients. Instruct patient not to become pregnant for 1 mo after being vaccinated with the rubella vaccine to protect any fetus from contracting the disease and having serious birth defects. Instruct on birth control methods to prevent pregnancy, if appropriate. Delay rubella vaccination in pregnancy until after childbirth, and give immediately prior to discharge from the hospital.
- ▶ Recognize anxiety related to test results, and provide emotional support if results are positive and the patient is pregnant. Encourage the family to seek counseling if concerned with pregnancy termination. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Decisions regarding elective abortion should take place in the presence of both parents. Provide a nonjudgmental, nonthreatening atmosphere for discussing the risks and difficulties of delivering and raising a developmentally challenged infant, as well as exploring other options (e.g., termination of pregnancy or adoption). Educate the patient regarding access to counseling services, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient in isolation precautions during time of communicability or contagion. Emphasize the need to return to have a convalescent blood sample taken in 7 to 14 days. Provide information regarding vaccine-preventable diseases where indicated (e.g., encephalitis, hepatitis A and B, human papillomavirus, influenza, measles, mumps, polio, rubella, smallpox, varicella, yellow fever). Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be

performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include CMV, and *Toxoplasma* antibody.
- ◆ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Rubeola Antibodies

SYNONYM/ACRONYM: Measles serology.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect immunofluorescence) Negative or less than a fourfold increase in titer.

DESCRIPTION: Measles is caused by a single-stranded ribonucleic acid (RNA) paramyxovirus that invades the respiratory tract and lymphoreticular tissues. It is transmitted by respiratory secretions and aerosolized droplets of the secretions. The incubation period is 10 to 11 days. Symptoms initially include conjunctivitis, cough, and fever. Koplik's spots develop 4 to 5 days later, followed by papular eruptions, body rash, and lymphadenopathy. The presence of immunoglobulin (Ig) M antibodies indicates acute infection. The presence of IgG antibodies indicates current or past infection. Susceptibility to measles is indicated by a negative reaction. Many laboratories use a qualitative assay that detects the presence of both IgM and IgG rubeola antibodies. IgM- and IgG-specific enzyme immunoassays are also available to help distinguish acute infection from immune status. A rise in titer greater than fourfold in paired specimens is an indication of current infection.

INDICATIONS:

- Determine resistance to or protection against measles virus
- Differential diagnosis of viral infection, especially in pregnant women with a history of exposure to measles

RESULT:**Positive findings in:**

- **Measles infection**

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

R

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to identify rubeola infection or immunity.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ◆ Obtain a history of exposure to measles.
- ◆ Obtain a history of the patient's immune and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that several tests may be necessary to confirm the diagnosis. Any individual positive result should be repeated in 7 to 14 days to monitor a change in titer. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient in isolation precautions during time of communicability or contagion. Emphasize the need to return to have a convalescent blood sample taken in 7 to 14 days. Provide information regarding vaccine-preventable diseases where indicated (e.g., encephalitis, hepatitis A and B, human papillomavirus, influenza, measles, mumps, polio, rubella, smallpox, varicella, yellow fever). Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include culture viral, rubella, and varicella.
- ◆ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Schirmer Tear Test

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Eyelids.

CONTRAST: N/A.

DESCRIPTION: The tear film, secreted by the lacrimal, Krause, and Wolfring glands, covers the surface of the eye. Blinking spreads tears over the eye and moves them toward an opening in the lower eyelid known as the punctum. Tears drain through the punctum into the nasolacrimal duct and into the nose. The Schirmer tear test simultaneously tests both eyes to assess lacrimal gland function by determining the amount of moisture accumulated on standardized filter paper or strips, held against the conjunctival sac of each eye. The Schirmer test measures both reflex and basic secretion of tears. The Schirmer test number two measures basic tear secretion and is used to evaluate the accessory glands of Krause and Wolfring. The test is performed by instilling a topical anesthetic before insertion of filter paper. The topical anesthetic inhibits reflex tearing of major lacrimal glands by the filter paper, allowing testing of the accessory glands.

INDICATIONS:

- Assess adequacy of tearing for contact lens comfort
- Assess suspected tearing deficiency

RESULT:

Normal findings in:

- 10 mm of moisture on test strip after 5 min. It may be slightly less than 10 mm in elderly patients.

Abnormal findings in:

- Tearing deficiency related to aging, dry eye syndrome, or Sjögren's syndrome
- Tearing deficiency secondary to leukemia, lymphoma, or rheumatoid arthritis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair clear imaging:

- Inability of the patient to remain still and cooperative during the test may interfere with the test results.
- Rubbing or squeezing the eyes may affect results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure measures the secretion of tears.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially topical anesthetic eyedrops.
- ◆ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ◆ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that no pain will be experienced during the test, but there may be moments of discomfort. Explain to the patient that some discomfort may be experienced after the test when the numbness wears off from anesthetic drops administered prior to the test. Inform the patient that the test is performed by a health care provider (HCP) and takes about 15 min to complete.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Seat the patient comfortably. Instruct the patient to look straight ahead, keeping the eyes open and unblinking.
- ▶ Instill topical anesthetic in each eye, as ordered, and provide time for it to work. Topical anesthetic drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semitransparent area of the eyeball where the cornea and sclera meet). Neither the dropper nor the bottle should touch the eyelashes. Insert a test strip in each eye. The strip should be folded over the mid-portion of both lower eyelids.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Assess for corneal abrasion caused by patient rubbing the eye before topical anesthetic has worn off.
- ▶ Instruct the patient to avoid rubbing the eyes for 30 min after the procedure.
- ▶ If appropriate, instruct the patient not to reinsert contact lenses for 2 hr.
- ▶ Recognize anxiety related to test results, and be supportive of pain related to decreased lacrimation or inflammation. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Provide contact information, if desired, for a general patient education Web site on the topic of eye care (e.g., www.allaboutvision.com).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ANA, refraction, RF, and slit-lamp biomicroscopy.
- ▶ Refer to the Ocular System table at the back of the book for related tests by body system.

Semen Analysis

SYNONYM/ACRONYM: N/A.

SPECIMEN: Semen from ejaculate specimen collected in a clean, dry, glass container known to be free of detergent. The specimen container should be kept at body temperature (37°C) during transportation.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination)

Volume	2–5 mL
Color	White or opaque
Appearance	Viscous (pours in droplets, not clumps or strings)
Clotting and liquefaction	Complete in 20–30 min
pH	7.2–8.0
Sperm count	Greater than 20 million/mL
Total sperm count	Greater than 40 million/ejaculate
Motility	At least 50%
Morphology	At least 70% normal oval-headed forms

DESCRIPTION: Semen analysis is a valid measure of overall male fertility. Semen contains a combination of elements produced by various parts of the male reproductive system. Spermatozoa are produced in the testes and account for only a small volume of seminal fluid. Fructose and other nutrients are provided by fluid produced in the seminal vesicles. The prostate gland provides acid phosphatase and other enzymes required for coagulation and liquefaction of semen. Sperm motility depends on the presence of a sufficient level of ionized calcium. If the specimen has an abnormal appearance (e.g., bloody, oddly colored, turbid), the patient may have an infection. Specimens can be tested with a leukocyte

esterase strip to detect the presence of white blood cells.

INDICATIONS:

- Assist in the diagnosis of azoospermia and oligospermia
- Evaluate infertility
- Evaluate effectiveness of vasectomy
- Evaluate the effectiveness of vasectomy reversal
- Support or disprove sterility in paternity suit

RESULT:

There is marked intraindividual variation in sperm count. Indications of suboptimal fertility should be investigated by serial analysis of two to three samples collected over several months. If abnormal results are obtained, additional testing may be requested.

Abnormality	Test Ordered	Normal Result
Decreased count	Fructose	Present (greater than 150 mg/dL)
Decreased motility with clumping	Male antisperm antibodies	Absent
Normal semen analysis with infertility	Female antisperm antibodies	Absent

Increased in: N/A

Decreased in:

- Hyperpyrexia (**Unusual and abnormal elevation in body temperature may result in insufficient sperm production**)
- Infertility (**Related to insufficient production of sperm**)
- Obstruction of ejaculatory system
- Orchitis (**Insufficient sperm production usually related to viral infection, rarely bacterial infection**)
- Postvasectomy period (**Obstruction of the vas deferens**)
- Primary and secondary testicular failure (**Congenital, as in Klinefelter syndrome, or acquired via infection**)
- Testicular atrophy (e.g., recovery from mumps)
- Varicocele (**Abnormal enlargement of the blood vessels in the scrotal area eventually damages testicular tissue and affects sperm production**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may decrease sperm count include arsenic, azathioprine, cannabis, cimetidine, cocaine, cyclophosphamide, estrogens, fluoxymesterone, ketoconazole, lead, methotrexate, methyltestosterone, nitrofurantoin, nitrogen mustard, procarbazine, sulfasalazine, and vincristine.
- Testicular radiation may decrease sperm counts.

- Cigarette smoking is associated with decreased production of semen.
- Caffeine consumption is associated with increased sperm density and number of abnormal forms.
- Delays in transporting the specimen and failure to keep the specimen warm during transportation are the most common reasons for specimen rejection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the diagnosis of male infertility.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's immune and reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Note any recent procedures that can interfere with test results.
- ♦ Review the procedure with the patient. Instruct the patient to refrain from any sexual activity for 3 days before specimen collection. Instruct the patient to bring the specimen to the laboratory within 30 to 60 min of collection and to keep the specimen warm (close to body temperature) during transportation. The requesting

health care provider (HCP) usually provides the patient with instructions for specimen collection. Address concerns about pain and explain that there should be no discomfort during the procedure.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Ejaculated Specimen:

- ▶ Ideally, the specimen is obtained by masturbation in a private location close to the laboratory. In cases in which the patient expresses psychological or religious concerns about masturbation, the specimen can be obtained during coitus interruptus, through the use of a condom, or through postcoital collection of samples from the cervical canal and vagina of the patient's sexual partner. The patient should be warned about the possible loss of the sperm-rich portion of the sample if coitus interruptus is the collection approach. If a condom is used, the patient must be carefully instructed to wash and dry the condom completely before use to prevent contamination of the specimen with spermicides.

Cervical Vaginal Specimen:

- ▶ Assist the patient to the lithotomy position on the examination table. A speculum is inserted, and the specimen is obtained by direct smear or aspiration of saline lavage.

Specimens Collected from Skin or Clothing:

- ▶ Dried semen may be collected by sponging the skin with a gauze soaked in saline or soaking the material in a saline solution.

General:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results. Provide a supportive, nonjudgmental environment when assisting a patient through the process of fertility testing. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Encourage the patient or family to seek counseling and other support services if concerned with infertility.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antisperm antibodies, cancer antigens, chlamydia group antibodies, estradiol, FSH, hysterosalpingography, laparoscopy gynecologic, LH, testosterone, and US scrotal.
- ▶ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Sickle Cell Screen

SYNONYM/ACRONYM: Sickle cell test.

SPECIMEN: Whole blood (1 mL) collected in a lavender-top (EDTA) tube.

REFERENCE VALUE: (Method: Hemoglobin high-salt solubility) Negative.

DESCRIPTION: The sickle cell screen is one of several screening tests for a group of hereditary hemoglobinopathies. The test is positive in the presence of rare sickling hemoglobin (Hgb) variants such as Hgb S and Hgb C Harlem. Hgb S results from an amino acid substitution during Hgb synthesis whereby valine replaces glutamic acid. Hemoglobin C Harlem results from the substitution of lysine for glutamic acid. Individuals with sickle cell disease have chronic anemia because the abnormal Hgb is unable to carry oxygen. The red blood cells of affected individuals are also abnormal in shape, resembling a crescent or sickle rather than the normal disk shape. This abnormality, combined with cell-wall rigidity, prevents the cells from passing through smaller blood vessels. Blockages in blood vessels result in hypoxia, damage, and pain. Individuals with the sickle cell trait do not have the clinical manifestations of the disease but may pass the disease on to children if the other parent has the trait (or the disease) as well.

INDICATIONS:

- Detect sickled red blood cells
- Evaluate hemolytic anemias

RESULT:

Positive findings in:

Deoxygenated Hgb S is insoluble in the presence of a high-salt solution and will form a cloudy turbid suspension when present.

- Combination of Hgb S with other hemoglobinopathies
- Hgb C Harlem anemia
- Sickle cell anemia
- Sickle cell trait
- Thalassemias

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase sickle cells in vitro include prostaglandins.
- A positive test does not distinguish between the sickle trait and sickle cell anemia; to make this determination, follow-up testing by Hgb electrophoresis should be performed.
- False-negative results may occur in children younger than 3 mo of age.
- False-negative results may occur in patients who have received a recent blood transfusion before specimen collection, as a result of the dilutional effect.
- False-positive results may occur in patients without the trait or disease who have received a blood transfusion from a sickle cell-positive donor; this effect can last for 4 mo after the transfusion.

- Test results are unreliable if the patient has pernicious anemia or polycythemia.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to determine the presence of hemoglobin S.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for

bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Advise the patient with sickle cell disease to avoid situations in which hypoxia may occur, such as strenuous exercise, staying at high altitudes, or traveling in an unpressurized aircraft. Obstetric and surgical patients with sickle cell anemia are at risk for hypoxia and therefore require close observation: Obstetric patients are at risk for hypoxia during the stress of labor and delivery, and surgical patients may become hypoxic while under general anesthesia.
- ▶ Recognize anxiety related to test results, and offer support, as appropriate. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services (www.sicklecelldisease.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that further testing may be indicated if results are positive. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy bone marrow, complete blood count, complete blood count, RBC morphology, ESR, Hgb electrophoresis, hemosiderin, LAP, MRI musculoskeletal, RBC cholinesterase, RBC indices, and US spleen.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Slit-Lamp Biomicroscopy

SYNONYM/ACRONYM: Slit-lamp examination.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: This noninvasive procedure is used to visualize the anterior portion of the eye and its parts, including the eyelids and eyelashes, sclera, conjunctiva, cornea, iris, lens, and anterior chamber, and to detect pathology of any of these areas of the eyes. The slit lamp has a binocular microscope and light source that can be adjusted to examine the fluid, tissues, and structures of the eyes. Special attachments to the slit lamp are used for special studies and more detailed views of specific areas. Dilating drops or mydriatics may be used to enlarge the pupil in order to allow the examiner to see the eye in greater detail. Mydriatics work either by temporarily paralyzing the muscle that makes the pupil smaller or by stimulating the iris dilator muscle. Patients with blue or hazel eyes will dilate faster than patients with brown eyes.

S

INDICATIONS:

- Detect conjunctival and corneal injuries by foreign bodies and determine if ocular penetration or anterior chamber hemorrhage is present
- Detect corneal abrasions, ulcers, or abnormal curvatures (keratocoma)

- Detect deficiency in tear formation indicative of lacrimal dysfunction causing dry eye disease that can lead to corneal erosions or infection
- Detect lens opacities indicative of cataract formation
- Determine the presence of blepharitis, conjunctivitis, hordeolum, entropion, ectropion, trachoma, scleritis, and iritis
- Evaluate the fit of contact lenses

RESULT:

Normal findings in:

- Normal anterior tissues and structures of the eyes

Abnormal findings in:

- Blepharitis
- Conjunctivitis
- Corneal abrasions
- Corneal ulcers
- Ectropion
- Entropion
- Hordeolum
- Iritis
- Keratoconus (abnormal curvatures)
- Lens opacities
- Scleritis
- Trachoma

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Patients with narrow-angle glaucoma if pupil dilation is performed, as dilation can initiate a severe and

sight-threatening open-angle attack.

- Patients with allergies to mydriatics if pupil dilation using mydriatics is performed.
- Inability of the patient to cooperate and remain still during the procedure because of age, significant pain, or mental status may interfere with the test results.
- Failure to follow medication restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure detects abnormalities in the external and anterior eye structures.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially mydriatics if dilation is to be performed.
- ▶ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests, diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Instruct the patient to remove contact lenses or glasses, as appropriate, unless the study is being done to check the fit and effectiveness of the contact lenses. Instruct the patient

regarding the importance of keeping the eyes open for the test.

- ▶ Review the procedure with the patient. Address concerns about pain and explain that mydriatics, if used, may cause blurred vision and sensitivity to light. There may also be a brief stinging sensation when the drop is put in the eye. Inform the patient that a health care provider (HCP) performs the test, in a quiet, darkened room, and that to evaluate both eyes, the test can take up 30 min (including time for the pupils to dilate before the test is actually performed).
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction.
- ▶ The patient should withhold eye medications (particularly mydriatic eye drops if the patient has glaucoma) for at least 1 day prior to the procedure.
- ▶ Ensure that the patient understands that he or she must refrain from driving until the pupils return to normal (about 4 hr) after the test and has made arrangements to have someone else be responsible for transportation after the test.

INTRATEST:

- ▶ Ensure that the patient has complied with medication restrictions and pretesting preparations; assure that eye medications, especially mydriatics, have been restricted for at least 1 day prior to the procedure.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ▶ Seat the patient comfortably. If dilation is to be performed, administer the ordered mydriatic to each eye and repeat in 5 to 15 min. Drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semitransparent area of the eyeball

where the cornea and sclera meet). Neither dropper nor bottle should touch the eyelashes.

- ◆ Ask the patient to place the chin in the chin rest and gently press the forehead against the support bar.
- ◆ The HCP places the slit lamp in front of the patient's eyes in line with the examiner's eyes. The external structures of the eyes are inspected with the special bright light and microscope of the slit lamp. The light is then directed into the patient's eyes to inspect the anterior fluids and structures, and is adjusted for shape, intensity, and depth needed to visualize these areas. Magnification of the microscope is also adjusted to optimize visualization of the eye structures.
- ◆ Special attachments and procedures can also be used to obtain further diagnostic information about the eyes. These may include, for example, a camera to photograph specific parts, gonioscopy to determine anterior chamber closure, and a cobalt blue filter to detect minute corneal scratches, breaks, and abrasions with corneal staining.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual medications, as directed by the HCP.
- ◆ Recognize anxiety related to test results, and encourage the family to recognize and be supportive of

impaired activity related to vision loss, anticipated loss of driving privileges, or the possibility of requiring corrective lenses (self-image). Discuss the implications of the abnormal test results on the patient's lifestyle. Provide contact information, if desired, for a general patient education Web site on the topic of eye care (e.g., www.allaboutvision.com).

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that visual acuity and responses to light may change. Suggest that the patient wear dark glasses after the test until the pupils return to normal size. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include color perception test, fluorescein angiography, gonioscopy, intraocular muscle function, intraocular pressure, nerve fiber analysis, refraction, Schirmer tear test, and visual field testing.
- ◆ Refer to the Ocular System table at the back of the book for related tests by body system.

Sodium, Blood

SYNONYM/ACRONYM: Serum Na⁺.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Ion-selective electrode)

Age	Conventional Units	SI Units (Conventional Units × 1)
Newborn	133–146 mEq/L	133–146 mmol/L
Infant	133–144 mEq/L	133–144 mmol/L
Child	135–145 mEq/L	135–145 mmol/L
Adult	135–145 mEq/L	135–145 mmol/L

DESCRIPTION: Sodium is the most abundant cation in the extracellular fluid and, together with the accompanying chloride and bicarbonate anions, accounts for 92% of serum osmolality. Sodium plays a major role in maintaining homeostasis in a variety of ways, including maintaining the osmotic pressure of extracellular fluid, regulating renal retention and excretion of water, maintaining acid-base balance, regulating potassium and chloride levels, stimulating neuromuscular reactions, and maintaining systemic blood pressure. *Hypernatremia* (elevated sodium level) occurs when there is excessive water loss or abnormal retention of sodium. *Hyponatremia* (low sodium level) occurs when there is inadequate sodium retention or inadequate intake.

INDICATIONS:

- Determine whole-body stores of sodium, because the ion is predominantly extracellular
- Monitor the effectiveness of drug therapy, especially diuretics, on serum sodium levels

RESULT:

Increased in:

- Azotemia (**Related to increased renal retention**)
- Burns (**Hemoconcentration related to excessive loss of free water**)

- Cushing's disease
- Dehydration
- Diabetes (**Dehydration related to frequent urination**)
- Diarrhea (**Water loss in excess of salt loss**)
- Excessive intake
- Excessive saline therapy (**IV fluids**)
- Excessive sweating (**Loss of free water can cause hemoconcentration**)
- Fever (**Loss of free water through sweating**)
- Hyperaldosteronism (**Excessive production of aldosterone increases renal absorption of sodium and increases blood levels**)
- Lactic acidosis (**Related to diabetes**)
- Nasogastric feeding with inadequate fluid (**Dehydration and hemoconcentration**)
- Vomiting (**Related to dehydration**)

Decreased in:

- Central nervous system disease
- Congestive heart failure (**Diminished renal blood flow due to reduced cardiac capacity decreases urinary excretion and increases blood sodium levels**)
- Cystic fibrosis (**Related to loss from chronic diarrhea; poor intestinal absorption**)
- Excessive antidiuretic hormone production (**Excessive loss through renal excretion**)
- Excessive use of diuretics (**Excessive loss through renal excretion; renal absorption is blocked**)
- Hepatic failure (**Hemodilution related to fluid retention**)

- Hypoproteinemia (**Related to fluid retention**)
- Insufficient intake
- IV glucose infusion (**Hypertonic glucose draws water into extracellular fluid and sodium is diluted**)
- Mineralocorticoid deficiency (Addison's disease) (**Inadequate production of aldosterone results in decreased absorption by the kidneys**)
- Nephrotic syndrome (**Related to decreased ability of renal tubules to reabsorb sodium**)

CRITICAL VALUES:

Hyponatremia: Less than 120 mmol/L

Hypertatremia: Greater than 160 mmol/L

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms especially fluid imbalance.

Signs and symptoms of hyponatremia include confusion, irritability, convulsions, tachycardia, nausea, vomiting, and loss of consciousness. Possible interventions include maintenance of airway, monitoring for convulsions, fluid restriction, and performance of hourly neurological checks. Administration of saline for replacement requires close attention to serum and urine osmolality.

Signs and symptoms of hypernatremia include restlessness, intense thirst, weakness, swollen tongue, seizures, and coma. Possible interventions include treatment of the underlying cause of water loss or sodium excess, which includes sodium restriction and administration of diuretics combined with IV solutions of 5% dextrose in water (D₅W).

INTERFERING FACTORS:

- Drugs that may increase serum sodium levels include anabolic steroids, angiotensin, bicarbonate,

carbenoxolone, cisplatin, corticotropin, cortisone, gamma globulin, and mannitol.

- Drugs that may decrease serum sodium levels include amphotericin B, bicarbonate, cathartics (excessive use), chlorpropamide, chlorthalidone, diuretics, ethacrynic acid, fluoxetine, furosemide, laxatives (excessive use), methyclothiazide, metolazone, nifedipine, quinethazone, theophylline (IV infusion), thiazides, and triamterene.
- Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, falsely decreasing the result. There is also the potential of contaminating the sample with the substance of interest, if it is present in the IV solution, falsely increasing the result.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate electrolyte balance.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Evaluate the patient for signs and symptoms of dehydration. Decreased skin turgor, dry mouth, and multiple longitudinal furrows in the tongue are symptoms of dehydration. Dehydration is a significant and common finding in geriatric and other patients in whom renal function has deteriorated.
- ▶ **Nutritional considerations:** If appropriate, educate patients with low sodium levels that the major source of dietary sodium is found in table salt. Many

foods, such as milk and other dairy products, are also good sources of dietary sodium. Most other dietary sodium is available through the consumption of processed foods. Patients on low-sodium diets should be advised to avoid beverages such as colas, ginger ale, sports drinks, lemon-lime sodas, and root beer. Many over-the-counter medications, including antacids, laxatives, analgesics, sedatives, and antitussives, contain significant amounts of sodium. The best advice is to emphasize the importance of reading all food, beverage, and medicine labels. In 1989, the Subcommittee on the 10th Edition of the RDA established 500 mg as the recommended maximum daily intake for dietary intake of sodium.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, aldosterone, anion gap, ANP, BNP, blood gases, BUN, calculus kidney stone panel, BUN, calcium, carbon dioxide, chloride, chloride sweat, cortisol, creatinine, DHEAS, echocardiography, glucose, insulin, ketones, lactic acid, lung perfusion scan, magnesium, osmolality, potassium, renin, urine sodium, and UA.
- ▶ Refer to the Endocrine and Genitourinary System tables at the back of the book for related tests by body system.

Sodium, Urine

SYNONYM/ACRONYM: Urine Na⁺

SPECIMEN: Urine (5 mL) from an unpreserved random or timed specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Ion-selective electrode)

Age	Conventional Units	SI Units (Conventional Units × 1)
6–10 yr		
Male	41–115 mEq/24 hr	41–115 mmol/24 hr
Female	20–69 mEq/24 hr	20–69 mmol/24 hr
10–14 yr		
Male	63–177 mEq/24 hr	63–177 mmol/24 hr
Female	48–168 mEq/24 h	48–168 mmol/24 hr
Adult	27–287 mEq/24 h	27–287 mmol/24 hr

Values vary markedly depending on dietary intake and hydration state.

DESCRIPTION: Regulating electrolyte balance is a major function of the kidneys. In normally functioning kidneys, urine sodium levels increase when serum levels are high and decrease when serum levels are low to maintain homeostasis. Analyzing these urinary levels can provide important clues to the functioning of the kidneys and other major organs. There is diurnal variation in excretion of sodium, with values lower at night. Urine sodium tests usually involve timed urine collections over a 12- or 24-hr period. Measurement of random specimens may also be requested.

- Evaluate known or suspected endocrine disorder
- Evaluate known or suspected renal disease
- Evaluate malabsorption disorders

RESULT:

Increased in:

- Adrenal failure (***Inadequate production of aldosterone results in decreased renal sodium absorption***)
- Diabetes (***Increased glucose levels result in hypertonic extracellular fluid; dehydration from excessive urination can cause hemoconcentration***)
- Diuretic therapy (***Medication causes sodium to be lost by the kidneys***)
- Excessive intake
- Renal tubular acidosis (***Related to diabetes***)

INDICATIONS:

- Determine potential cause of renal calculi

- Salt-losing nephritis (**Related to diminished capacity of the kidneys to reabsorb sodium**)

Decreased in:

- Adrenal hyperfunction (**Overproduction of aldosterone and other corticosteroids stimulate renal absorption of sodium decreasing urine sodium levels**)
- Congestive heart failure (**Decreased renal blood flow related to diminished cardiac output**)
- Diarrhea (**Related to decreased intestinal absorption; a decrease in blood levels will cause sodium to be retained by the kidneys and will lower urine sodium levels**)
- Excessive sweating (**Excessive loss of sodium through sweat; sodium will be retained by the kidneys**)
- Extrarenal sodium loss with adequate hydration
- Insufficient intake
- Postoperative period (first 24 to 48 hr)
- Prerenal azotemia
- Sodium retention (**Premenstrual**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase urine sodium levels include acetazolamide, acetylsalicylic acid, amiloride, ammonium chloride, azosemide, benzthiazide, bumetanide, calcitonin, chlorothiazide, clopamide, cyclothiazide, diampamide, dopamine, ethacrynic acid, furosemide, hydrocortisone, hydroflumethiazide, isosorbide, levodopa, mercurial diuretics, methyclothiazide, metolazone, polythiazide, quinethazone,

spironolactone, sulfates, tetracycline, thiazides, torasemide, triamterene, trichlormethiazide, triflocin, verapamil, and vincristine.

- Drugs that may decrease urine sodium levels include aldosterone, anesthetics, angiotensin, corticosteroids, cortisone, etodolac, indomethacin, levarterenol, lithium, and propranolol.
- Sodium levels are subject to diurnal variation (output being lowest at night), which is why 24-hr collections are recommended.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate acute renal failure and acute oliguria, and to assist in the differential diagnosis of hyponatremia.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date, and time of collection.

Random Specimen (Collect in Early Morning):

Clean-catch specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a

small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- ▶ Include on the collection container's label the amount of urine, test start

and stop times, and any foods or medications that can affect test results.

General:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

- ▶ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.

- ▶ **Nutritional considerations:** If appropriate, educate patients with low sodium levels that the major source of dietary sodium is found in table salt. Many foods, such as milk and other dairy products, are also good sources of dietary sodium. Most other dietary sodium is available through the consumption of processed foods.

Patients on low-sodium diets should be advised to avoid beverages such as colas, ginger ale, sports drinks, lemon-lime sodas, and root beer. Many over-the-counter medications, including antacids, laxatives, analgesics, sedatives, and antitussives, contain significant amounts of sodium. The best advice is to emphasize the importance of reading all food, beverage, and medicine labels. In 1989, the Subcommittee on the 10th Edition of the RDA established 500 mg as the recommended

maximum daily intake for dietary intake of sodium.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, aldosterone, anion gap, ANP, BNP, blood gases, BUN, calcium, calculus kidney stone panel, carbon dioxide, chloride, chloride sweat, cortisol, creatinine, DHEAS, echocardiography, glucose, insulin, ketones, lactic acid, lung perfusion scan, magnesium, osmolality, potassium, renin, sodium, and UA.
- ▶ Refer to the Endocrine and Genitourinary System tables at the back of the book for related tests by body system.

Spondee Speech Recognition Threshold

S

SYNONYM/ACRONYM: SRT, Speech Reception Threshold.

AREA OF APPLICATION: Ears.

CONTRAST: N/A.

DESCRIPTION: This noninvasive speech audiometric procedure measures the degree of hearing loss for speech. The speech recognition threshold is the lowest hearing level at which speech can barely be recognized or understood. In this test, a number of spondaic words are presented to the patient at different intensities. Spondaic words, or spondees, are words containing two syllables that are equally accented or emphasized when they are spoken to the patient. The SRT is defined as the lowest hearing level at which the patient correctly repeats 50% of a list of spondaic words. Examples are airplane, hot dog, outside, ice cream, and baseball.

INDICATIONS:

- Determine appropriate gain during hearing aid selection
- Determine the extent of hearing loss related to speech recognition, as evidenced by the faintest level at which spondee words are correctly repeated
- Differentiate a real hearing loss from pseudohypacusis
- Verify pure tone results

RESULT:

Normal findings in:

- Normal spondee threshold of about 6 to 10 dB (decibels) of the normal pure tone threshold with 50% of the words presented being correctly repeated at the appropriate intensity (see monograph titled “Audiometry, Hearing Loss”)
- Normal speech recognition with 90% to 100% of the words

presented being correctly repeated at an appropriate intensity

Abnormal findings in:

- Conductive hearing loss
- High-frequency hearing loss
- Sensorineural hearing loss (acoustic nerve impairment)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- Inability of the patient to cooperate or remain still during the procedure because of age or mental status may interfere with the test results.
- Unfamiliarity with the language the words are presented in or with the words themselves will alter the results.
- Improper placement of the earphones and inconsistency in frequency of word presentation will affect results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure measures hearing loss related to speech.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's known or suspected hearing loss, including type and cause; ear conditions with treatment regimens; ear surgery; and other tests and procedures to assess and diagnose hearing deficit.

- ◆ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Ensure that the patient understands words and sounds in the language to be used for the test. Inform the patient that a series of words that change from loud to soft tones will be presented using earphones and that he or she will be asked to repeat the word. Explain that each ear is tested separately. Address concerns about pain and explain that no discomfort will be experienced during the test. Inform the patient that a health care provider (HCP) performs the test, in a quiet, soundproof room, and that the evaluation takes 5 to 10 min.
- ◆ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ◆ Seat the patient on a chair in a soundproof booth. Place the earphones on the patient's head and secure them over the ears. The audiometer is set at 20 dB above the known pure tone threshold obtained from audiometry. The test represents hearing levels at speech frequencies of 500, 1000, and 2000 Hz.

- ◆ The spondee words are presented to the ear with the best auditory response using a speech audiometer. The intensity is decreased and then increased to the softest sound at which the patient is able to hear the words and respond correctly to 50% of them. The procedure is then repeated for the other ear.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Recognize anxiety related to test results, and be supportive of activity related to impaired hearing and perceived loss of independence. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Speech-Language-Hearing Association (www.asha.org).
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ A related test is hearing loss audiometry.
- ◆ Refer to the Auditory System table at the back of the book for related tests by body system.

Stereotactic Biopsy, Breast

SYNONYM/ACRONYM: N/A.

SPECIMEN: Breast tissue or cells.

REFERENCE VALUE: (Method: Macroscopic and microscopic examination of tissue) No abnormal cells or tissue.

DESCRIPTION: A stereotactic breast biopsy is helpful when a mammogram or ultrasound examination shows a mass, a cluster of microcalcifications (tiny calcium deposits that are closely grouped together), or an area of abnormal tissue change, usually with no lump being felt on a careful breast examination. A number of biopsy instruments and methods are utilized with x-ray guidance. They include core biopsy, which uses a large-bore needle to remove a generous sample of breast tissue, and a vacuum-assisted needle biopsy device. As an alternative to an open core surgical biopsy, which removes an entire breast lump for microscopic analysis, a narrow needle may be passed through the skin into the area under investigation. This accomplished with the help of special breast x-rays. Images of the breast are obtained with a mammography machine, and the images are recorded in a computer. An initial x-ray locates the abnormality and two stereo views are obtained, each angled 15° to either side of the initial image. The computer calculates how much the area of interest has changed with each image and is able to determine the exact site in three-dimensional space. A small sample of breast

tissue is obtained and can show whether the breast mass is cancerous or not. A pathologist examines the tissue that was removed and makes a final diagnosis to allow for effective treatment.

INDICATIONS:

- A mammogram showing a suspicious cluster of small calcium deposits
- A mammogram showing a suspicious solid mass that cannot be felt on breast examination
- Evidence of breast lesion by palpation, mammography, or ultrasound
- New mass or area of calcium deposits present at a previous surgery site
- Observable breast changes such as “peau d’orange” skin, scaly skin of the areola, drainage from the nipple, or ulceration of the skin
- Patient preference for a nonsurgical method of lesion assessment
- Structure of the breast tissue is distorted

RESULT:

- Positive findings in carcinoma of the breast

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- This procedure is contraindicated in patients with bleeding disorders.

Factors that may impair clear imaging:

- Failure to restrict food intake before the study
- Metallic objects (e.g., jewelry, body rings, dental amalgams) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Complications of the procedure include hemorrhage, infection at the insertion site, and cardiac arrhythmias.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Consultation with a health care practitioner (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses a breast mass.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex or anesthetics.

- ▶ Obtain a history of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the medications the patient is taking, including anticoagulant therapy, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). It is recommended that use be discontinued 14 days before surgical procedures. The requesting HCP and laboratory should be advised if the patient regularly uses these products so that their effects can be taken into consideration when reviewing results.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain will be experienced during the test, or there may be moments of discomfort. Inform the patient that the procedure is performed in a special room, usually a mammography suite, by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids or sedatives. Usually normal saline is infused.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area of the procedure.
- ▶ Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant.
- ▶ Instruct the patient to fast and restrict fluids for 4 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

- ◆ The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.

INTRATEST:

- ◆ Ensure that the patient has complied with dietary and medication restrictions for 4 hr prior to the procedure.
- ◆ Ensure that anticoagulant therapy has been withheld for the appropriate number of days prior to the procedure. Number of days to withhold medication is dependent on the type of anticoagulant. Notify the HCP if patient anticoagulant therapy has not been withheld.
- ◆ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ◆ Have emergency equipment readily available.
- ◆ If the patient has a history of severe allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ◆ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate specimen containers with the corresponding patient demographics, date and time of collection, and site location (left or right breast).
- ◆ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ◆ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ◆ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ◆ Place the patient in the prone or sitting position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ◆ A local anesthetic is injected at the site, and a small incision is made or a needle inserted.
- ◆ Instruct the patient to inhale deeply and hold his or her breath while the images are taken, and then to exhale after the images are taken.
- ◆ Instruct the patient to take slow, deep breaths if nausea occurs during the

procedure. Monitor and administer an antiemetic agent if ordered. Ready an emesis basin for use.

- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ◆ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ◆ Place tissue samples in properly labeled specimen containers, and promptly transport the specimens to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual diet and medications, as directed by the HCP.
- ◆ Monitor vital signs and neurological status every 15 min for 1 hour, then every 2 hr for 4 hr, and then as ordered by the HCP. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ◆ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ Observe the biopsy site for bleeding, inflammation, or hematoma formation.
- ◆ Advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ◆ Instruct the patient in the care and assessment of the site. Instruct the patient to report any redness, edema, bleeding, or pain at the biopsy site. Instruct the patient to immediately report chills or fever. Instruct the patient to keep the site clean and change the dressing as needed.
- ◆ Recognize anxiety related to test results, and be supportive of the potential perceived loss of body image. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Cancer Society (www.cancer.org).

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in

therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include biopsy breast, CEA and cancer antigens, mammography, MRI breast, and US breast.
- Refer to the Reproductive System table at the back of the book for related tests by body system.

Synovial Fluid Analysis

SYNONYM/ACRONYM: Arthrocentesis, joint fluid analysis, knee fluid analysis.

SPECIMEN: Synovial fluid collected in a red-top tube for antinuclear antibodies (ANAs), complement, crystal examination, protein, rheumatoid factor (RF), and uric acid; sterile (red-top) tube for microbiological testing; lavender-top (EDTA) tube for complete blood count (CBC) and differential; gray-top (sodium fluoride [NaFl]) tube for glucose; green-top (heparin) tube for lactic acid and pH.

REFERENCE VALUE: (Method: Macroscopic evaluation of appearance; spectrophotometry for glucose, lactic acid, protein, and uric acid; Gram stain, acid-fast stain, and culture for microbiology; microscopic examination of fluid for cell count and evaluation of crystals; ion-selective electrode for pH; nephelometry for RF and C3 complement; indirect fluorescence for ANAs)

Color	Colorless to Pale Yellow
Clarity	Clear
Viscosity	High
ANA	Parallels serum level
C3	Parallels serum level
Glucose	Less than 10 mg/dL of blood level
Lactic acid	5–20 mg/dL
pH	7.2–7.4
Protein	Less than 3 g/dL
RF	Parallels serum level
Uric acid	Parallels serum level
Crystals	None present
RBC count	None
WBC count	Less than 0.23 10 ³ /mm ³ (or 200/mm ³)
Neutrophils	Less than 25%
WBC morphology	No abnormal cells or inclusions
Gram stain and culture	No organisms present
AFB smear and culture	No AFB present

ANA = antinuclear antibodies; C3 = complement; RF = rheumatoid factor; RBC = red blood cell; WBC = white blood cell; AFB = acid-fast bacilli.

DESCRIPTION: Synovial fluid analysis is performed via arthrocentesis, an invasive procedure involving insertion of a needle into the joint space. Synovial effusions are associated with disorders or injuries involving the joints. The most commonly aspirated joint is the knee, although samples also can be obtained from the shoulder, hip, elbow, wrist, and ankle, if clinically indicated. Joint disorders can be classified into five categories: noninflammatory, inflammatory, septic, crystal-induced, and hemorrhagic.

INDICATIONS:

- Assist in the evaluation of joint effusions
- Differentiate gout from pseudogout

RESULT:

Fluid Values Increased in:

- *Acute bacterial infection:* White blood cell (WBC) count greater than $50 \times 10^3/\text{mm}^3$, marked predominance of neutrophils (greater than 90% neutrophils), positive Gram stain, positive cultures, possible presence of rice bodies, increased lactic acid (produced by bacteria), and complement levels paralleling those found in serum (may be elevated or decreased)
- *Gout:* WBC count variable: $0.5\text{--}200 \times 10^3/\text{mm}^3$ with a predominance of neutrophils (90% neutrophils), presence of monosodium urate crystals, increased uric acid, and complement levels paralleling those of serum (may be elevated or decreased)
- *Osteoarthritis, traumatic arthritis degenerative joint disease:* WBC count less than $3 \times 10^3/\text{mm}^3$ with less than 25% neutrophils and the presence of cartilage cells
- *Pseudogout:* Presence of calcium pyrophosphate crystals

- *Rheumatoid arthritis:* WBC count $3\text{--}50 \times 10^3/\text{mm}^3$ with a predominance of neutrophils (greater than 70% neutrophils), presence of rago-cyte cells and possibly rice bodies, presence of cholesterol crystals if effusion is chronic, increased protein, increased lactic acid, and presence of rheumatoid factor
- *Systemic lupus erythematosus (SLE):* $3\text{--}50 \times 10^3/\text{mm}^3$ with a predominance of neutrophils, presence of SLE cells, and presence of antinuclear antibodies
- *Trauma, joint tumors, or hemophilic arthritis:* Elevated RBC count, increased protein level, and presence of fat droplets (if trauma involved)
- *Tuberculous arthritis:* WBC count $2\text{--}100 \times 10^3/\text{mm}^3$ with a predominance of neutrophils (up to 90% neutrophils), possible presence of rice bodies, presence of cholesterol crystals if effusion is chronic, in some cases a positive culture and smear for acid-fast bacilli (results frequently negative), and lactic acid

Fluid Values Decreased in (Analytes in Parentheses are Decreased):

- Acute bacterial arthritis (glucose and pH)
- Gout (glucose)
- Rheumatoid arthritis (glucose, pH, and complement)
- SLE (glucose, pH, and complement)
- Tuberculous arthritis (glucose and pH)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Blood in the sample from traumatic arthrocentesis may falsely elevate the RBC count.
- Undetected hypoglycemia or hyperglycemia may produce misleading glucose values.

- Refrigeration of the sample may result in an increase in monosodium urate crystals secondary to decreased solubility of uric acid; exposure of the sample to room air with a resultant loss of carbon dioxide and rise in pH encourages the formation of calcium pyrophosphate crystals.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to identify the presence and assist in the management of joint disease.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's immune and musculoskeletal systems, especially any bleeding disorders and other symptoms, as well as results of previously performed laboratory tests, diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Inform the patient that it may be necessary to remove hair from the site before the procedure. Address concerns about pain and explain that a sedative and/or analgesia will be administered to promote relaxation and reduce discomfort prior to needle insertion through the joint space. Explain that any discomfort with the needle insertion will be minimized with local anesthetics and systemic analgesics. Explain that the anesthetic injection may cause an initial stinging sensation. Explain that, after the skin has been anesthetized, a large needle will be inserted through the joint space, and a "popping" sensation may be experienced as the needle penetrates the joint. Inform the patient that the procedure is performed by a health care provider (HCP) specializing in this procedure. The procedure usually takes approximately 20 min to complete.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no fluid restrictions unless by medical direction. Fasting for at least 12 hr before the procedure is recommended if fluid glucose measurements are included in the analysis. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and medication restrictions and pretesting preparations; assure that food has been restricted for at least 12 hr prior to the procedure. Ensure that anticoagulant medications and aspirin have been withheld, as ordered.
- ▶ Assemble the necessary equipment, including an arthrocentesis tray with solution for skin preparation, local anesthetic, a 20-mL syringe, needles of various sizes, sterile drapes, and sterile gloves for the tests to be performed.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement during the local anesthetic and the procedure.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date and time of collection, and site location, especially left or right.

- ▶ Assist the patient into a comfortable sitting or supine position, as appropriate.
- ▶ Prior to the administration of general or local anesthesia, shave the site and cleanse it with an antiseptic solution, and drape the area with sterile towels.
- ▶ After the local anesthetic is administered, the needle is inserted at the collection site, and fluid is removed by syringe. Manual pressure may be applied to facilitate fluid removal.
- ▶ If medication is injected into the joint, the syringe containing the sample is detached from the needle and replaced with the one containing the drug. The medication is injected with gentle pressure. The needle is withdrawn, and digital pressure is applied to the site for a few minutes. If there is no evidence of bleeding, a sterile dressing is applied to the site. An elastic bandage can be applied to the joint.
- ▶ Monitor the patient for complications related to the procedure (allergic reaction, anaphylaxis).
- ▶ Place samples in properly labeled specimen containers and promptly transport the specimens to the laboratory for processing and analysis. If bacterial culture and sensitivity tests are to be performed, record on the specimen containers any antibiotic therapy the patient is receiving.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and medications, as directed by the HCP.
- ▶ After local anesthesia, monitor vital signs and compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Assess puncture site for bleeding, bruising, inflammation, and excessive drainage of synovial fluid approximately every 4 hr for 24 hr and daily thereafter for several days.
- ▶ Instruct the patient to report excessive pain, bleeding, or swelling to the requesting HCP immediately. Report to

- HCP if severe pain is present or the patient is unable to move the joint.
- ▶ Assess for nausea and pain. Administer antiemetic and analgesic medications as needed and as directed by the HCP.
- ▶ Instruct the patient to apply an ice pack to the site for 24 to 48 hr.
- ▶ Administer antibiotics, as ordered, and instruct the patient in the importance of completing the entire course of antibiotic therapy even if no symptoms are present.
- ▶ Recognize anxiety related to test results, and offer support. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient or caregiver to handle linen and dispose of dressings cautiously, especially if septic arthritis is suspected. Instruct the patient to avoid excessive use of the joint for several days to prevent pain and swelling. Instruct the patient to return for a follow-up visit as scheduled. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies anti-cyclic citrullinated, ANA, arthrogram, arthroscopy, BMD, bone scan, CRP, cholesterol, complete blood count, complete blood count, WBC count and differential, ESR, MRI musculoskeletal, radiography bone, RF, synovial fluid analysis, and uric acid.
- ▶ Refer to the Immune and Musculoskeletal System tables at the back of the book for related tests by body system.

Syphilis Serology

SYNONYM/ACRONYM: Automated reagin testing (ART), fluorescent treponemal antibody testing (FTA-ABS), microhemagglutination–*Treponema pallidum* (MHA-TP), rapid plasma reagin (RPR), treponemal studies, Venereal Disease Research Laboratory (VDRL) testing.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Dark-field microscopy, rapid plasma reagin, enzyme-linked immunosorbent assay [ELISA], microhemagglutination, fluorescence) Nonreactive or absence of treponemal organisms.

DESCRIPTION: There are numerous methods for detecting *Treponema pallidum*, the organism known to cause syphilis. Syphilis serology is routinely ordered as part of a prenatal work-up and is required for evaluating donated blood units before release for transfusion. Selection of the proper testing method is important. Automated reagin testing (ART), rapid plasma reagin (RPR), and Venereal Disease Research Laboratory (VDRL) testing should be used for screening purposes. Fluorescent treponemal antibody testing (FTA-ABS) and microhemagglutination–*Treponema pallidum*, (MHA-TP) are confirmatory methods for samples that screen positive or reactive. Cerebrospinal fluid should be tested only by the FTA-ABS method. Cord blood should not be submitted for testing by any of the aforementioned methods; instead, the mother's serum should be tested to establish whether the infant should be treated.

INDICATIONS:

- Monitor effectiveness of treatment for syphilis
- Screen for and confirm the presence of syphilis

RESULT:

Positive findings in:

- Syphilis

False-Positive or False-Reactive Findings in Screening (RPR, VDRL) Tests:

- Infectious:
 - Bacterial endocarditis
 - Chancroid
 - Chickenpox
 - Human immunodeficiency virus
 - Infectious mononucleosis
 - Leprosy
 - Leptospirosis
 - Lymphogranuloma venereum
 - Malaria
 - Measles
 - Mumps
 - Mycoplasma pneumoniae*
 - Pneumococcal pneumonia
 - Psittacosis
 - Relapsing fever
 - Rickettsial disease
 - Scarlet fever
 - Trypanosomiasis

Tuberculosis
 Vaccinia (live or attenuated)
 Viral hepatitis

- Noninfectious:
 - Advanced cancer
 - Advancing age
 - Chronic liver disease
 - Connective tissue diseases
 - IV drug use
 - Multiple blood transfusions
 - Multiple myeloma and other immunological disorders
 - Narcotic addiction
 - Pregnancy

False-Positive or False-Reactive Findings in Confirmatory (FTA-ABS, MHA-TP) Tests:

- Infectious:
 - Infectious mononucleosis
 - Leprosy
 - Leptospirosis
 - Lyme disease
 - Malaria
 - Relapsing fever
- Noninfectious:
 - Systemic lupus erythematosus

Negative findings in: N/A

CRITICAL VALUES:

Note and immediately report to the health care provider (HCP) positive results and related symptoms.

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to diagnose syphilis infection.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of exposure.
- ▶ Obtain a history of the patient's immune and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and offer support. Counsel the patient, as appropriate, regarding the risk of transmission and proper

prophylaxis, and reinforce the importance of strict adherence to the treatment regimen. Inform the patient that positive findings must be reported to local health department officials, who will question him or her regarding sexual partners. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Inform the patient that repeat testing may be needed at 3-mo intervals for 1 yr to monitor the effectiveness of treatment. Answer any questions or address any concerns voiced by the patient or family.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Offer support, as appropriate, to patients who may be the victim of rape or sexual assault. Educate the patient

regarding access to counseling services. Provide a nonjudgmental, nonthreatening atmosphere for a discussion during which risks of sexually transmitted diseases are explained. It is also important to discuss problems the patient may experience (e.g., guilt, depression, anger).

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include acid phosphatase, cerebrospinal fluid analysis, *Chlamydia* group antibody, culture bacterial anal, Gram stain, hepatitis B, hepatitis C, HIV, and β_2 -microglobulin.
- ▶ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Testosterone, Total

SYNONYM/ACRONYM: N/A.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Immunochemiluminometric assay [ICMA])

Age	Conventional Units	SI Units (Conventional Units × 0.0347)
1–5 mo		
<i>Male</i>	1–177 ng/dL	0.03–6.14 nmol/L
<i>Female</i>	1–5 ng/dL	0.03–0.17 nmol/L
6–11 mo		
<i>Male</i>	2–7 ng/dL	0.07–0.24 nmol/L
<i>Female</i>	2–5 ng/dL	0.07–0.17 nmol/L
1–5 yr		
<i>Male & Female</i>	0–10 ng/dL	0.00–0.35 nmol/L
6–7 yr		
<i>Male</i>	0–20 ng/dL	0.00–0.69 nmol/L
<i>Female</i>	0–10 ng/dL	0.00–0.35 nmol/L
8–10 yr		
<i>Male</i>	0–25 ng/dL	0.00–0.87 nmol/L
<i>Female</i>	0–30 ng/dL	0.00–1.0 nmol/L
11–12 yr		
<i>Male</i>	0–350 ng/dL	0.00–12.1 nmol/L
<i>Female</i>	0–50 ng/dL	0.00–1.74 nmol/L
13–15 yr		
<i>Male</i>	15–500 ng/dL	0.52–17.35 nmol/L
<i>Female</i>	0–50 ng/dL	0.00–1.74 nmol/L
Adult		
<i>Male</i>	241–827 ng/dL	8.36–28.70 nmol/L
<i>Female</i>	15–70 ng/dL	0.52–2.43 nmol/L

Tanner Stage

	Male	Female
I	2–23	2–10
II	5–70	5–30
III	15–280	10–30
IV	105–545	15–40
V	265–800	10–40

DESCRIPTION: Testosterone is the major androgen responsible for sexual differentiation. In males, testosterone is made by the Leydig cells in the testicles and is responsible for spermatogenesis and the development of

secondary sex characteristics.

In females, the ovary and adrenal gland secrete small amounts of this hormone; however, most of the testosterone in females comes from the metabolism of androstenedione. In males, a testicular, adrenal, or pituitary tumor can cause an overabundance of testosterone, triggering precocious puberty. In females, adrenal tumors, hyperplasia, and medications can cause an overabundance of this hormone, resulting in masculinization or hirsutism.

INDICATIONS:

- Assist in the diagnosis of hypergonadism
- Assist in the diagnosis of male sexual precocity before age 10
- Distinguish between primary and secondary hypogonadism
- Evaluate hirsutism
- Evaluate male infertility

RESULT:**Increased in:**

- Adrenal hyperplasia (*Oversecretion of the androgen precursor DHEA*)
- Adrenocortical tumors (*Oversecretion of the androgen precursor DHEA*)
- Hirsutism (*Any condition that results in increased production of testosterone or its precursors*)
- Hyperthyroidism (*High thyroxine levels increase the production of sex hormone binding protein, which increases measured levels of total testosterone*)
- Idiopathic sexual precocity (*Related to stimulation of testosterone production by elevated levels of luteinizing hormone [LH]*)
- Polycystic ovaries (*High estrogen levels increase the production of sex hormone binding protein, which increases measured levels of total testosterone*)
- Syndrome of androgen resistance
- Testicular or extragonadal tumors (*Related to excessive secretion of testosterone*)
- Trophoblastic tumors during pregnancy
- Virilizing ovarian tumors

Decreased in:

- Anovulation
- Cryptorchidism (*Related to dysfunctional testes*)

- Delayed puberty
- Down syndrome (*Related to diminished or dysfunctional testes*)
- Excessive alcohol intake (*Alcohol inhibits secretion of testosterone*)
- Hepatic insufficiency (*Related to decreased binding protein and reflects decreased measured levels of total testosterone*)
- Impotence (*Decreased testosterone levels can result in impotence*)
- Klinefelter's syndrome (*Chromosome abnormality XXY associated with testicular failure*)
- Malnutrition
- Myotonic dystrophy (*Related to testicular atrophy*)
- Orchiectomy (*Testosterone production occurs in the testes*)
- Primary and secondary hypogonadism
- Primary and secondary hypopituitarism
- Uremia

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase testosterone levels include barbiturates, bromocriptine, cimetidine, flutamide, gonadotropin, levonorgestrel, mifepristone, moclobemide, nafarelin (males), nilutamide, oral contraceptives, rifampin, and tamoxifen.
- Drugs that may decrease testosterone levels include cyclophosphamide, cyproterone, danazol, dexamethasone, diethylstilbestrol, digoxin, D-Trp-6-LHRH, fenoldopam, goserelin, ketoconazole, leuprolide, magnesium sulfate, medroxyprogesterone, methylprednisone, nandrolone,

oral contraceptives, pravastatin, prednisone, pyridoglutethimide, spironolactone, stanozolol, tetracycline, and thioridazine.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to assess gonadal and adrenal function.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's endocrine and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in

Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.

- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ Recognize anxiety related to test results, and offer support, as appropriate. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include angiography adrenal gland scan, ACE, antibodies antisperm, biopsy thyroid, chromosome analysis, CT renal, DHEAS, estradiol, FSH, LH, PTH, RAIU, semen analysis, US scrotal, thyroid scan, TSH, and thyroxine.
- ◆ Refer to the Endocrine and Reproductive System tables at the back of the book for related test by body system.

Thyroglobulin

SYNONYM/ACRONYM: Tg.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Chemiluminescent enzyme immunoassay)

Age	Conventional Units	SI Units (Conventional Units × 1)
Cord blood	5–65 ng/mL	5–65 mcg/L
1 d	6–93 ng/mL	6–93 mcg/L
10 d	9–148 ng/mL	9–148 mcg/L
Premature infant		
1 d	107–395 ng/mL	107–395 mcg/L
3 d	49–163 ng/mL	49–163 mcg/L
1 mo	17–63 ng/mL	17–63 mcg/L
7–12 yr	20–50 ng/mL	20–50 mcg/L
12–18 yr	9–27 ng/mL	9–27 mcg/L
Adult	0–50 ng/mL	0–50 mcg/L

DESCRIPTION: Thyroglobulin is an iodinated glycoprotein secreted by follicular epithelial cells of the thyroid gland. It is the storage form of the thyroid hormones thyroxine (T_4) and triiodothyronine (T_3). When thyroid hormones are released into the bloodstream, they split from thyroglobulin in response to thyroid-stimulating hormone. Values greater than 55 ng/mL are indicative of tumor recurrence in athyrotic patients.

INDICATIONS:

- Assist in the diagnosis of subacute thyroiditis
- Assist in the diagnosis of suspected disorders of excess thyroid hormone
- Management of differentiated or metastatic cancer of the thyroid
- Monitor response to treatment of goiter

- Monitor T_4 therapy in patients with solitary nodules

RESULT:

Increased in:

Thyroglobulin is secreted by normal, abnormal, and cancerous thyroid tissue cells.

- Differentiated thyroid cancer
- Graves' disease (untreated)
(Autoimmune destruction of thyroid tissue cells)
- Surgery or irradiation of the thyroid
(Elevated levels indicate residual or disseminated carcinoma)
- T_4 -binding globulin deficiency
- Thyroiditis *(Related to leakage from inflamed, damaged thyroid tissue cells)*
- Thyrotoxicosis

Decreased in:

- Administration of thyroid hormone
(Feedback loop suppresses production)

- Congenital athyrosis (neonates)
(Related to insufficient synthesis)
- Thyrotoxicosis factitia

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may decrease thyroglobulin levels include neomycin and T_4 .
- Autoantibodies to thyroglobulin can cause decreased values.
- Recent thyroid surgery or needle biopsy can interfere with test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate thyroid gland function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid

the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, albumin, ACE, antibodies thyroglobulin, biopsy thyroid, copper, follicle-stimulating hormone, growth hormone, luteinizing hormone, PTH, protein, RAIU, TBII, thyroid scan, TSH, TSI, T_4 , free T_4 , T_3 , free T_3 , and US thyroid.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Thyroid-Binding Inhibitory Immunoglobulin

SYNONYM/ACRONYM: Thyrotropin receptor antibodies, thyrotropin-binding inhibitory immunoglobulin, TBII.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Radioreceptor) Less than 10% inhibition. (*Note:* In patients with Graves' disease, inhibition is expected to be 10% to 100%.)

RESULT:

Increased in:

Antibodies block the action of TSH and result in hyperthyroid conditions.

- Graves' disease
- Hyperthyroidism (various forms)

- Maternal thyroid disease
- Neonatal thyroid disease
- Toxic goiter

Decreased in: N/A

CRITICAL VALUES: N/A

Find and print out the full monograph at DavisPlus (davisplus.fadavis.com, keyword Van Leeuwen).

Thyroid Scan

SYNONYM/ACRONYM: Thyroid scintiscan, iodine thyroid scan, technetium thyroid scan.

AREA OF APPLICATION: Thyroid.

CONTRAST: Oral radioactive iodine or IV technetium-99m pertechnetate.

DESCRIPTION: The thyroid scan is a nuclear medicine study performed to assess thyroid size, shape, position, and function; it is useful for evaluating thyroid nodules, multinodular goiter, and thyroiditis; assisting in the differential diagnosis of masses in the neck, base of the tongue, and mediastinum; and ruling out possible ectopic thyroid tissue in these areas. Thyroid

scanning is performed after oral administration of radioactive iodine-123 (I-123) or I-131, or IV injection of technetium-99m (Tc-99m). Increased or decreased uptake by the thyroid gland and surrounding area and tissue is noted: Areas of increased radionuclide uptake ("hot spots") are caused by hyperfunctioning thyroid nodules, which are usually nonmalignant; areas of decreased

uptake (“cold spots”) are caused by hypofunctioning nodules, which are more likely to be malignant. Ultrasound imaging may be used to determine if the cold spot is a solid, semi-cystic lesion or a pure cyst (cysts are rarely cancerous). To determine whether the cold spot depicts a malignant neoplasm, however, a biopsy must be performed.

- Fibrosis
- Goiter
- Graves' disease (diffusely enlarged, hyperfunctioning gland)
- Hematoma
- Metastasis
- Plummer's disease (nodular hyperfunctioning gland)
- Thyroiditis (Hashimoto's)
- Thyrotoxicosis
- Tumors, benign or malignant

CRITICAL VALUES: N/A

INDICATIONS:

- Assess palpable nodules and differentiate between a benign tumor or cyst and a malignant tumor
- Assess the presence of a thyroid nodule or enlarged thyroid gland
- Detect benign or malignant thyroid tumors
- Detect causes of neck or substernal masses
- Detect forms of thyroiditis (e.g., acute, chronic, Hashimoto's)
- Detect thyroid dysfunction
- Differentiate between Graves' disease and Plummer's disease, both of which cause hyperthyroidism
- Evaluate thyroid function in hyperthyroidism and hypothyroidism (analysis combined with interpretation of laboratory tests, thyroid function panel including thyroxine and triiodothyronine, and thyroid uptake tests)

RESULT:

Normal findings in:

- Normal size, contour, position, and function of the thyroid gland with homogeneous uptake of the radionuclide

Abnormal findings in:

- Adenoma
- Cysts

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus or mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Other nuclear scans or iodinated contrast medium radiographic studies done within the previous 24 to 48 hr
- Ingestion of foods containing iodine (iodized salt) or medications containing iodine (cough syrup, potassium iodide, vitamins, Lugol's solution, thyroid replacement medications), which can decrease the uptake of the radionuclide
- Antithyroid medications (propylthiouracil), corticosteroids, antihistamines, warfarin, sulfonamides, nitrates, corticosteroids, thyroid hormones, and isoniazid, which can decrease the uptake of the radionuclide
- Increased uptake of iodine in persons with an iodine-deficient diet or who are on phenothiazine therapy

- Vomiting and severe diarrhea, which can affect absorption of orally administered radionuclide
- Gastroenteritis, which can interfere with absorption of orally administered radionuclide
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Improper injection of the radionuclide that allows the tracer to seep deep into the muscle tissue can produce erroneous hot spots.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses thyroid function and structure.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.

- ▶ Ensure thyroid blood tests are completed prior to this procedure.
- ▶ Note any recent procedures that can interfere with test results, including examinations using iodinated contrast medium or radioactive nuclides.
- ▶ Radiographic procedures done with iodinated contrast medium should be scheduled after this procedure is completed.
- ▶ Obtain a history of results of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test. Inform the patient that the procedure is performed in a nuclear medicine department, usually by a HCP specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast for 8 to 12 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions for 8 to 12 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.

- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to lie still during the procedure because movement produces unclear images.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer sedative to a child or to an uncooperative adult, as ordered.
- ▶ Tc-99m pertechnetate is injected IV 20 min before scanning.
- ▶ If oral radioactive nuclide is used instead, administer I-123 24 hr before scanning.
- ▶ Place the patient in a supine position on a flat table to obtain images of the neck area.
- ▶ Remove the needle or catheter and apply a pressure dressing over the puncture site.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site.
- ▶ Instruct the patient to resume pretesting diet as directed by the HCP.
- ▶ Advise the patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body, unless contraindicated. Tell the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to flush the toilet immediately, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, angiography adrenal, biopsy thyroid, calcium, CT renal, cortisol, glucose, radioactive iodine uptake, sodium, thyroglobulin, thyroid antibodies, TBII, thyroid scan, TSH, TT3, and US thyroid.
- ▶ Refer to the Endocrine System table in the back of the book for related tests by body system.

Thyroid-Stimulating Hormone

SYNONYM/ACRONYM: Thyrotropin, TSH.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube; for a neonate, use filter paper.

REFERENCE VALUE: (Method: Immunoassay)

Age	Conventional Units	SI Units (Conventional Units × 1)
Neonates–3 d	Less than 20 microinternational units/mL	Less than 20 milliinternational units/L
Adults	0.4–4.2 microinternational units/mL	0.4–4.2 milliinternational units/L

DESCRIPTION: Thyroid-stimulating hormone (TSH) is produced by the pituitary gland in response to stimulation by thyrotropin-releasing hormone (TRH), a hypothalamic-releasing factor. TRH regulates the release and circulating levels of thyroid hormones in response to variables such as cold, stress, and increased metabolic need. Thyroid and pituitary function can be evaluated by TSH measurement. TSH exhibits diurnal variation, peaking between midnight and 4 a.m. and troughing between 5 and 6 p.m. TSH values are high at birth but reach adult levels in the first week of life. Elevated TSH levels combined with decreased thyroxine (T_4) levels indicate hypothyroidism and thyroid gland dysfunction. In general, decreased TSH and T_4 levels indicate secondary congenital hypothyroidism and pituitary hypothalamic dysfunction. A normal TSH level and a

depressed T_4 level may indicate (1) hypothyroidism owing to a congenital defect in T_4 -binding globulin, or (2) transient congenital hypothyroidism owing to hypoxia or prematurity. Early diagnosis and treatment in the neonate are crucial for the prevention of cretinism and mental retardation.

INDICATIONS:

- Assist in the diagnosis of congenital hypothyroidism
- Assist in the diagnosis of hypothyroidism or hyperthyroidism or suspected pituitary or hypothalamic dysfunction
- Differentiate functional euthyroidism from true hypothyroidism in debilitated individuals

RESULT:

Increased in:

A decrease in thyroid hormone levels activates the feedback loop to increase production of TSH.

- Congenital hypothyroidism in the neonate (filter paper test)

T

- Ectopic TSH-producing tumors (lung, breast)
- Primary hypothyroidism
- Secondary hyperthyroidism owing to pituitary hyperactivity
- Thyroid hormone resistance
- Thyroiditis (Hashimoto's autoimmune disease)

Decreased in:

An increase in thyroid hormone levels activates the feedback loop to decrease production of TSH.

- Excessive thyroid hormone replacement
- Graves' disease
- Primary hyperthyroidism
- Secondary hypothyroidism
(**Related to pituitary involvement that decreases production of TSH**)
- Tertiary hypothyroidism (**Related to hypothalamic involvement that decreases production of TRH**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and hormones that may increase TSH levels include amiodarone, benserazide, erythrosine, flunarizine (males), iobenzamic acid, iodides, lithium, methimazole, metoclopramide, morphine, propranolol, radiographic agents, TRH, and valproic acid.
- Drugs and hormones that may decrease TSH levels include acetylsalicylic acid, amiodarone, anabolic steroids, carbamazepine, corticosteroids, dopamine, glucocorticoids, hydrocortisone, insulin-like growth factor-I, interferon-alfa-2b, iodamide, josamycin, levodopa, levothyroxine, methergoline, nifedipine, pyridoxine, T₄, and triiodothyronine (T₃).
- Failure to let the filter paper sample dry may affect test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the test is used to evaluate thyroid gland function.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ◆ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ◆ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient demographics, date, and time of collection. Perform a venipuncture.
- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

Filter Paper Test (Neonate):

Obtain kit and cleanse heel with antiseptic. Observe standard precautions, and follow the general guidelines in Appendix A. Use gauze to dry the stick area completely. Perform heel stick, gently squeeze infant's heel, and touch filter paper to the puncture site. Completely fill the circles on the filter paper, saturating the filter paper with blood. Apply pressure to the heel stick with a gauze pad to stop the bleeding. Allow the filter paper to dry thoroughly, label the specimen, and promptly transport it to the laboratory. Alternatively, if a specimen collection kit is used, follow instructions for labeling and mailing to the testing laboratory.

POST-TEST:

A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ACTH, albumin, ACE, antibodies antithyroglobulin, biopsy thyroid, copper, follicle-stimulating hormone, growth hormone, luteinizing hormone, PTH, protein, RAIU, thyroglobulin, TSI, TBII, thyroid scan, T_4 , free T_4 , T_3 , free T_3 , and US thyroid.
- Refer to the Endocrine System table at the back of the book for related tests by body system.

Thyroid-Stimulating Immunoglobulin

SYNONYM/ACRONYM: Thyrotropin receptor antibodies, TSI.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Animal cell transfection with luciferase marker) Less than 130% of basal activity.

DESCRIPTION: There are two functional types of thyroid receptor immunoglobulins: *thyroid-stimulating immunoglobulin (TSI)* and *thyroid-binding inhibitory immunoglobulin (TBII)*. TSI reacts with the receptors, activates intracellular enzymes, and promotes epithelial cell activity that operates outside the feedback regulation

for thyroid-stimulating hormone (TSH); TBII blocks the action of TSH and is believed to cause certain types of hyperthyroidism (see monograph titled "Thyroid-Binding Inhibitory Immunoglobulin"). These antibodies were formerly known as *long-acting thyroid stimulators*. High levels in pregnancy may have some predictive value for

neonatal thyrotoxicosis: A positive result indicates that the antibodies are stimulating (TSI); a negative result indicates that the antibodies are blocking (TBII). TSI testing measures thyroid receptor immunoglobulin levels in the evaluation of thyroid disease.

INDICATIONS:

- Follow-up to positive TBII assay in differentiating antibody stimulation from neutral or suppressing activity
- Monitor hyperthyroid patients at risk for relapse or remission

RESULT:

Increased in:

Graves' disease (*This form of hyperthyroidism has an autoimmune component; the antibodies stimulate release of thyroid hormones outside the feedback loop that regulates TSH levels*)

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Lithium may cause false-positive TBII results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate thyroid gland function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further

testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ACTH, albumin, ACE, antibodies antithyroglobulin, biopsy thyroid, copper, follicle-stimulating hormone, growth hormone, luteinizing hormone, PTH, protein, RAIU, thyroglobulin, TBII, thyroid scan, TSH, T_4 , free T_4 , T_3 , free T_3 , and US thyroid.
- ◆ Refer to the Endocrine System table at the back of the book for related tests by body system.

Thyroxine-Binding Globulin

SYNONYM/ACRONYM: TBG.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunochemiluminometric assay [ICMA])

Age	Conventional Units	SI Units (Conventional Units × 10)
0–1 wk	3–8 mg/dL	30–80 mg/L
1–12 mo	1.6–3.6 mg/dL	16–36 mg/L
14 yr–adult	1.2–2.5 mg/dL	12–25 mg/L
Adult	1.3–3.3 mg/dL	13–33 mg/L
Pregnancy, third trimester	4.7–5.9 mg/dL	47–59 mg/L
Oral contraceptives	1.5–5.5 mg/dL	15–55 mg/L

DESCRIPTION: Thyroxine-binding globulin (TBG) is the predominant protein carrier for circulating thyroxine (T_4) and triiodothyronine (T_3). T_4 -binding prealbumin and T_4 -binding albumin are the other transport proteins. Conditions that affect TBG levels and binding capacity also affect free T_3 and free T_4 levels.

INDICATIONS:

- Differentiate elevated T_4 due to hyperthyroidism from increased TBG binding in euthyroid patients
- Evaluate hypothyroid patients
- Identify deficiency of or excess TBG due to hereditary abnormality

RESULT:

Increased in:

- Acute intermittent porphyria (*Pathophysiology is not well understood*)

- Estrogen therapy (**TBG is increased in the presence of exogenous or endogenous estrogens**)
- Genetically high TBG (Rare)
- Hyperthyroidism (**Related to increased levels of total thyroxine available for binding**)
- Infectious hepatitis and other liver diseases (**Pathophysiology is not well understood**)
- Neonates
- Pregnancy (**TBG is increased in the presence of exogenous or endogenous estrogens**)

Decreased in:

- Acromegaly
- Chronic hepatic disease (**General decrease in protein synthesis**)
- Genetically low TBG
- Major illness (**General decrease in protein synthesis**)
- Marked hypoproteinemia, malnutrition (**General decrease in protein synthesis**)
- Nephrotic syndrome (**General increase in protein loss**)
- Ovarian hypofunction (**TBG is decreased in the absence of estrogens**)
- Surgical stress (**General decrease in protein synthesis**)
- Testosterone-producing tumors (**TBG is decreased in the presence of testosterone**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and hormones that may increase TBG levels include estrogens, oral contraceptives, perphenazine, and tamoxifen.
- Drugs that may decrease TBG levels include anabolic steroids, androgens, asparaginase, corticosteroids, corticotropin, danazol, phenytoin, and propranolol.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate thyroid gland function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor

progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies antithyroglobulin, thyroglobulin, TBII, thyroid scan, TSH, TSI, T_3 , free T_3 , T_4 , free T_4 , and US thyroid.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Thyroxine, Free

SYNONYM/ACRONYM: Free T_4 , FT₄.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Immunoassay)

Age	Conventional Units	SI Units (Conventional Units × 12.9)
Newborn	0.8–2.8 ng/dL	10–36 pmol/L
1–12 mo	0.8–2.0 ng/dL	10–26 pmol/L
1–18 yr	0.8–1.7 ng/dL	10–22 pmol/L
Adult	0.8–1.5 ng/dL	10–19 pmol/L

DESCRIPTION: Thyroxine (T_4) is a hormone produced and secreted by the thyroid gland. Newborns are commonly tested for decreased T_4 levels by a filter paper method (see monograph titled “Thyroxine, Total”). Most T_4 in the serum (99.97%) is bound to thyroxine-binding globulin (TBG), prealbumin, and albumin. The remainder (0.03%) circulates as unbound or free T_4 , which is the

physiologically active form. Levels of free T_4 are proportional to levels of total T_4 . The advantage of measuring free T_4 instead of total T_4 is that, unlike total T_4 measurements, free T_4 levels are not affected by fluctuations in TBG levels; as a result, free T_4 levels are considered the most accurate indicator of T_4 and its thyrometabolic activity. Free T_4 measurements are useful in evaluating thyroid disease

when thyroid-stimulating hormone (TSH) levels alone provide insufficient information. Free T_4 and TSH levels are inversely proportional. Measurement of free T_4 is also recommended during treatment for hyperthyroidism, until symptoms have abated and levels have decreased into the normal range.

INDICATIONS:

- Evaluate signs of hypothyroidism or hyperthyroidism
- Monitor response to therapy for hypothyroidism or hyperthyroidism

RESULT:

Increased in:

- Hyperthyroidism (***Thyroxine is produced independently of stimulation by TSH***)
- Hypothyroidism treated with T_4 (***Laboratory tests do not distinguish between endogenous and exogenous sources***)

Decreased in:

- Hypothyroidism (***Thyroid hormones are not produced in sufficient quantities regardless of TSH levels***)
- Pregnancy (late)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase free T_4 levels include acetylsalicylic acid, amiodarone, halofenate, heparin, iopanoic acid, levothyroxine, methimazole, and radiographic agents.
- Drugs that may decrease free T_4 levels include amiodarone, anabolic steroids, asparaginase, methadone, methimazole, oral contraceptives, and phenylbutazone.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate thyroid gland function.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ♦ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ♦ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ♦ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in

therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include ACTH, albumin, ACE, antibodies antithyroglobulin, biopsy thyroid, copper, follicle-stimulating hormone, growth hormone, luteinizing hormone, PTH, protein, RAIU, thyroglobulin, TBII, thyroid scan, TSH, TSI, T_4 , T_3 , free T_3 , and US thyroid.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Thyroxine, Total

SYNONYM/ACRONYM: T_4 .

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Immunoassay).

Age	Conventional Units	SI Units (Conventional Units × 12.9)
1–3 d	11.8–22.6 mcg/dL	152–292 nmol/L
1–2 wk	9.8–16.6 mcg/dL	126–214 nmol/L
1–4 mo	7.2–14.4 mcg/dL	93–186 nmol/L
5–12 mo	7.8–16.5 mcg/dL	101–213 nmol/L
1–5 yr	7.3–15.0 mcg/dL	94–194 nmol/L
5–10 y	6.4–13.3 mcg/dL	83–172 nmol/L
10–15 y	5.6–11.7 mcg/dL	72–151 nmol/L
Adult		
Male	4.6–10.5 mcg/dL	59–135 nmol/L
Female	5.5–11.0 mcg/dL	71–142 nmol/L
Pregnant female	5.5–16.0 mcg/dL	71–155 nmol/L
Over 60 yr	5.0–10.7 mcg/dL	65–138 nmol/L

DESCRIPTION: Thyroxine (T_4) is a hormone produced and secreted by the thyroid gland. Newborns are commonly tested for decreased T_4 levels by a filter

paper method. Most T_4 in the serum (99.97%) is bound to thyroxine-binding globulin (TBG), prealbumin, and albumin. The remainder (0.03%) circulates

as unbound or free T_4 , which is the physiologically active form. Levels of free T_4 are proportional to levels of total T_4 . The advantage of measuring free T_4 instead of total T_4 is that, unlike total T_4 measurements, free T_4 levels are not affected by fluctuations in TBG levels; as a result, free T_4 levels are considered the most accurate indicator of T_4 and its thyrometabolic activity (see monograph titled “Thyroxine, Free”).

INDICATIONS:

- Evaluate signs of hypothyroidism or hyperthyroidism and neonatal screening for congenital hypothyroidism (required in all 50 states)
- Evaluate thyroid response to protein deficiency associated with severe illnesses
- Monitor response to therapy for hypothyroidism or hyperthyroidism

RESULT:

Increased in:

- Acute psychiatric illnesses (*Pathophysiology is unknown although there is a relationship between thyroid hormone levels and certain types of mental illness*)
- Excessive intake of iodine (*Iodine is rapidly taken up by the body to form thyroxine*)
- Hepatitis (*Related to decreased production of TBG by damaged liver cells*)
- Hyperthyroidism (*Thyroxine is produced independently of stimulation by TSH*)
- Obesity
- Thyrotoxicosis due to Graves' disease (*Thyroxine is produced independently of stimulation by TSH*)

- Thyrotoxicosis factitia (*Laboratory tests do not distinguish between endogenous and exogenous sources*)

Decreased in:

- Decreased TBG (*Nephrotic syndrome, liver disease, gastrointestinal protein loss, malnutrition*)
- Hypothyroidism (*Thyroid hormones are not produced in sufficient quantities regardless of TSH levels*)
- Panhypopituitarism (*The dysfunctional pituitary gland does not secrete enough thyrotropin to stimulate the thyroid to produce thyroxine*)
- Strenuous exercise

CRITICAL VALUES:

Hypothyroidism:

Less than 2.0 mcg/dL

Hyperthyroidism: Greater than 20.0 mcg/dL

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms.

At levels less than 2.0 mcg/dL, the patient is at risk for myxedema coma. Signs and symptoms of severe hypothyroidism include hypothermia, hypotension, bradycardia, hypoventilation, lethargy, and coma. Possible interventions include airway support, hourly monitoring for neurological function and blood pressure, and administration of IV thyroid hormone.

At levels greater than 20.0 mcg/dL, the patient is at risk for thyroid storm. Signs and symptoms of severe hyperthyroidism include hyperthermia, diaphoresis, vomiting, dehydration, and shock. Possible interventions include supportive treatment for shock, fluid and electrolyte replacement for dehydration, and administration of anti-thyroid drugs (propylthiouracil and Lugol's solution).

INTERFERING FACTORS:

- Drugs that may increase T_4 levels include amiodarone, amphetamines, corticosteroids, ether, fluorouracil, glucocorticoids, halofenate, insulin, iobenzamic acid, iopanoic acid, ipodate, levarterenol, levodopa, levothyroxine, opiates, oral contraceptives, phenothiazine, and prostaglandins.
- Drugs, substances, and treatments that may decrease T_4 levels include acetylsalicylic acid, aminoglutethimide, aminosalicic acid, amiodarone, anabolic steroids, anticonvulsants, asparaginase, barbiturates, carbimazole, chlorpromazine, chlorpropamide, cholestyramine, clofibrate, cobalt, colestipol, corticotropin, cortisone, cotrimoxazole, cytostatic therapy, danazol, dehydroepiandrosterone, dexamethasone, diazepam, diazo dyes (e.g., Evans blue), dinitrophenol, ethionamide, fenclofenac, halofenate, hydroxyphenylpyruvic acid, interferon alfa-2b, iothiouracil, iron, isotretinoin, liothyronine, lithium, lovastatin, methimazole, methylthiouracil, mitotane, norethindrone, penicillamine, penicillin, phenylacetic acid derivatives, phenylbutazone, potassium iodide, propylthiouracil, reserpine, salicylate, sodium nitroprusside, stanozolol, sulfonyleureas, tetrachlorothyronine, tolbutamide, and triiodothyronine (T_3).

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate thyroid gland function.
- ▶ Obtain a history of the patient's complaints, including a list of known

allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing,

treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ACTH, albumin, ACE, antibodies antithyroglobulin, biopsy thyroid, copper, follicle-stimulating hormone, growth hormone, luteinizing hormone, PTH, protein, RAIU, thyroglobulin, TBII, thyroid scan, TSH, TSI, free T₄, T₃, free T₃, and US thyroid.
- Refer to the Endocrine System table at the back of the book for related tests by body system.

Toxoplasma Antibody

SYNONYM/ACRONYM: Toxoplasmosis serology, toxoplasmosis titer.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect fluorescent antibody) Negative or less than a fourfold increase in titer.

DESCRIPTION: Toxoplasmosis is a severe, generalized granulomatous central nervous system disease caused by the protozoan *Toxoplasma gondii*. Transmission to humans occurs by ingesting undercooked meat or handling contaminated matter such as cat litter. Immunoglobulin (Ig) M antibodies develop approximately 5 days after infection and can remain elevated for 3 wk to several mo. IgG antibodies develop 1 to 2 wk after infection and can remain elevated for months or years. *Toxoplasma* serology is part of the TORCH (*toxoplasmosis*, rubella, cytomegalovirus, and herpes simplex type 2) panel routinely performed on pregnant women. Fetal infection during the first trimester can cause spontaneous abortion or congenital

defects. Immunocompromised individuals are also at high risk for serious complications if infected. The presence of IgM antibodies indicates acute or congenital infection; the presence of IgG antibodies indicates current or past infection.

INDICATIONS:

- Assist in establishing a diagnosis of toxoplasmosis
- Document past exposure or immunity
- Serological screening during pregnancy

RESULT:**Positive findings in**

- Toxoplasma* infection

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of toxoplasmosis and to document history of previous exposure or immunity.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of exposure.
- ▶ Obtain a history of the patient's immune and reproductive systems, a history of other potential sources of exposure, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that several tests may be necessary to confirm the diagnosis. Any individual positive result should be repeated in 3 wk to monitor a change in titer. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the

patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and provide emotional support if results are positive and the patient is pregnant and/or immunocompromised. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient in isolation precautions during time of communicability or contagion. Emphasize the need to return to have a convalescent blood sample taken in 3 wk. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CMV, fetal fibronectin, and rubella.
- ▶ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Transferrin

SYNONYM/ACRONYM: Siderophilin, TRF.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Nephelometry)

Age	Conventional Units	SI Units (Conventional Units × 0.01)
Newborn	130–275 mg/dL	1.3–2.75 g/L
Adult		
Male	215–365 mg/dL	2.2–3.6 g/L
Female	250–380 mg/dL	2.5–3.8 g/L

DESCRIPTION: Transferrin is a glycoprotein formed in the liver. It transports circulating iron obtained from dietary intake and red blood cell breakdown. Transferrin carries 50% to 70% of the body's iron; normally it is approximately one-third saturated. Inadequate transferrin levels can lead to impaired hemoglobin synthesis and anemia. Transferrin is subject to diurnal variation, and it is responsible for the variation in levels of serum iron throughout the day. (See monograph titled "Iron-Binding Capacity [Total], Transferrin, and Iron Saturation.")

INDICATIONS:

- Determine the iron-binding capacity of the blood
- Evaluate iron metabolism in iron-deficiency anemia
- Evaluate nutritional status
- Screen for hemochromatosis

RESULT:

Increased in:

- Estrogen therapy (*Estrogen stimulates the liver to produce transferrin*)

- Iron-deficiency anemia (*The liver produces transferrin in response to decreased iron levels*)
- Pregnancy (*The liver produces transferrin in response to anemia of pregnancy*)

Decreased in:

- Acute or chronic infection (*A negative acute phase reactant protein whose levels decrease in response to inflammation*)
- Cancer (especially of the gastrointestinal tract) (*Related to malnutrition*)
- Excessive protein loss from renal disease (*Increased loss from damaged kidney*)
- Hepatic damage (*Related to decreased synthesis in the liver*)
- Hereditary atransferrinemia
- Malnutrition (*Protein deficient diet does not provide the nutrients required for synthesis*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase transferrin levels include carbamazepine, danazol, mestranol, and oral contraceptives.

- Drugs that may decrease transferrin levels include cortisone and dextran.
- Transferrin levels are subject to diurnal variation and should be collected in the morning, when levels are highest.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is primarily used to evaluate nutritional status (e.g., iron-deficiency anemia).
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to fast for at least 12 hr before specimen collection.
- ▶ There are no fluid or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 12 hr prior to the procedure.

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ *Nutritional considerations:* Educate the patient with abnormal iron values that numerous factors affect the absorption of iron, enhancing or decreasing absorption regardless of the original content of the iron-containing dietary source. Consumption of large amounts of alcohol damages the intestine and allows increased absorption of iron. A high intake of calcium and ascorbic acid also increases iron absorption. Iron absorption after a meal is also increased by factors in meat, fish, or poultry. Iron absorption is decreased by the absence (gastric resection) or diminished presence (use of antacids) of gastric acid. Phytic acids from cereals, tannins from tea and coffee, oxalic acid from vegetables, and minerals such as copper, zinc, and manganese interfere with iron absorption.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.

Answer any questions or address any concerns voiced by the patient or family. Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include A/G, cancer antigens, complete blood count, ferritin, iron/TIBC, prealbumin, RBC count, RBC indices, RBC morphology, and total protein.
- ▶ Refer to the Hematopoietic System table at the back of the book for related tests by body system.

Triglycerides

SYNONYM/ACRONYM: Trigs, TG.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

ATP III Classification	Conventional Units	SI Units (Conventional Units × 0.0113)
Normal	Less than 150 mg/dL	Less than 1.7 mmol/L
Borderline High	150–199 mg/dL	1.7–2.2 mmol/L
High	200–499 mg/dL	2.2–5.6 mmol/L
Very High	Greater than 500 mg/dL	Greater than 5.6 mmol/L

DESCRIPTION: Triglycerides are a combination of three fatty acids and one glycerol molecule. They are necessary to provide energy for various metabolic processes. Excess triglycerides are stored in adipose tissue, and the fatty acids provide the raw materials needed for conversion to glucose (gluconeogenesis) or for direct use as an energy source. Although fatty acids originate in the diet, many are also derived from unused glucose and amino acids that the liver converts into stored

energy. Beyond triglyceride, total cholesterol, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) cholesterol values, other important risk factors must be considered. The Framingham algorithm can assist in estimating the risk of developing coronary artery disease (CAD) within a 10-yr period. The National Cholesterol Education Program (NCEP) also provides important guidelines. The latest NCEP guidelines for target lipid levels, major risk factors, and therapeutic

interventions are outlined in Adult Treatment Panel III (ATP III). Triglyceride levels vary by age, gender, weight, and race:

Levels increase with age.

Levels are higher in men than in women (among women, those who take oral contraceptives have levels that are 20 to 40 mg/dL higher than those who do not).

Levels are higher in overweight and obese people than in those with normal weight.

Levels in African Americans are approximately 10 to 20 mg/dL lower than in whites.

INDICATIONS:

- Evaluate known or suspected disorders associated with altered triglyceride levels
- Identify hyperlipoproteinemia (hyperlipidemia) in patients with a family history of the disorder
- Monitor the response to drugs known to alter triglyceride levels
- Screen adults who are either over 40 y.o. or obese to estimate the risk for atherosclerotic cardiovascular disease

RESULT:

Increased in:

- Acute myocardial infarction (*Elevated TG is identified as an independent risk factor in the development of CAD*)
- Alcoholism (*Related to decreased breakdown of fats in the liver and increased blood levels*)
- Anorexia nervosa (*Compensatory increase, secondary to starvation*)
- Chronic ischemic heart disease (*Elevated TG is identified as an independent risk factor in the development of CAD*)

- Cirrhosis (*Increased TG blood levels related to decreased breakdown of fats in the liver*)
- Glycogen storage disease (*G6PD deficiency, e.g., von Gierke's disease, results in hepatic overproduction of very-low-density lipoprotein [VLDL] cholesterol, the TG-rich lipoprotein*)
- Gout (*TG is frequently elevated in patients with gout, possibly related to alterations in apolipoprotein E genotypes*)
- Hyperlipoproteinemia (*Related to increase in transport proteins*)
- Hypertension (*Associated with elevated TG, which is identified as an independent risk factor in the development of CAD*)
- Hypothyroidism (*Significant relationship between elevated TG and decreased metabolism*)
- Impaired glucose tolerance (*Increase in insulin stimulates production of TG by liver*)
- Metabolic syndrome (*Syndrome consisting of obesity, high blood pressure, and insulin resistance*)
- Nephrotic syndrome (*Related to absence or insufficient levels of lipoprotein lipase to remove circulating TG and to decreased catabolism of TG-rich VLDL lipoproteins*)
- Obesity (*Significant and complex relationship between obesity and elevated TG*)
- Pancreatitis (*Acute and chronic; related to effects on insulin production*)
- Pregnancy (*Increased demand for production of hormones related to pregnancy*)
- Renal failure (*Related to diabetes; elevated insulin levels stimulate production of TG by liver*)
- Respiratory distress syndrome (*Related to artificial lung surfactant used for therapy*)
- Stress (*Related to poor diet; effect of hormones secreted under*

stressful situations that affect glucose levels)

- Syndrome X (**Metabolic syndrome consisting of obesity, high blood pressure, and insulin resistance**)
- Werner's syndrome (**Clinical features resemble Syndrome X**)

Decreased in:

- End-stage liver disease (**Related to cessation of liver function that results in decreased production of TG and TG transport proteins**)
- Hyperthyroidism (**Related to increased catabolism of VLDL transport proteins and general increase in metabolism**)
- Hypolipoproteinemia and abetalipoproteinemia (**Related to decrease in transport proteins**)
- Intestinal lymphangiectasia
- Malabsorption disorders (**Inadequate supply from dietary sources**)
- Malnutrition (**Inadequate supply from dietary sources**)

CRITICAL VALUES: N/A**INTERFERING FACTORS:**

- Drugs that may increase triglyceride levels include acetylsalicylic acid, aldatense, atenolol, bendroflumethiazide, cyclosporine, danazol, glucocorticoids, oral contraceptives, oxprenolol, pindolol, prazosin, propranolol, tamoxifen, and timolol.
- Drugs and substances that may decrease triglyceride levels include ascorbic acid, bezafibrate, captopril, carvedilol, celiprolol, chenodeoxycholic acid, cholestyramine, cilazapril, ciprofibrate, clofibrate, colestipol, dextrothyroxine, doxazosin, enalapril, eptastatin, fenofibrate, flaxseed oil, gemfibrozil, glucagon, halofenate, insulin, levonorgestrel, lovastatin, medroxyprogesterone, metformin, nafenopin, niacin, niceritrol,

pinacidil, pindolol, pravastatin, prazosin, probucol, simvastatin, and verapamil.

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate and monitor hyperlipidemia.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's cardiovascular and gastrointestinal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ The patient should fast for 12 hr before specimen collection. Ideally, the patient should be on a stable diet for 3 wk and avoid alcohol consumption for 3 days before specimen collection. Protocols may vary from facility to facility.
- ♦ There are no medication restrictions, unless by medical direction.

INTRATEST:

- ♦ Ensure that the patient has complied with dietary restrictions and other pretesting preparations; assure that food has been restricted for at least 12 hr prior to the procedure.

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ **Nutritional considerations:** Increased triglyceride levels may be associated with atherosclerosis and CAD. Nutritional therapy is recommended for individuals identified to be at high risk for developing CAD. If overweight, these patients should be encouraged to achieve a normal weight. The American Heart Association has Step 1 and Step 2 diets that may be helpful in achieving a goal of lowering total cholesterol and triglyceride levels. The Step 1 diet emphasizes a reduction in foods high in saturated fats and cholesterol. Red meats, eggs, and dairy products are the major sources of saturated fats and cholesterol. If triglycerides are also elevated, patients should be advised to eliminate or reduce alcohol and simple carbohydrates from their diet. The Step 2 diet recommends stricter reductions.
- ▶ **Sensitivity to social and cultural issues:** Numerous studies point to the increased prevalence of excess body weight in American children and adolescents. Experts estimate that 25% of American children ages 6 to 11 yr are obese. The medical, social, and emotional consequences of excess body weight are significant.
- ▶ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Special attention should be given to instructing the pediatric patient and caregiver regarding health risks and weight control. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Heart Association (www.americanheart.org), or the National Heart, Lung, and Blood Institute (www.nhlbi.nih.gov).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, atrial natriuretic peptide, blood gases, BNP, calcium (total and ionized), cholesterol (total, HDL, and LDL), CT cardiac scoring, C-reactive protein, CK and isoenzymes, echocardiography, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI chest, myocardial infarct scan, myocardial perfusion heart scan, myoglobin, PET heart, potassium, and troponin.
- ▶ Refer to the Cardiovascular and Gastrointestinal System tables at the back of the book for related tests by body system.

Triiodothyronine, Free

SYNONYM/ACRONYM: Free T_3 , FT_3 .

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunoassay)

Age	Conventional Units	SI Units (Conventional Units \times 0.01)
Children and adults	260–480 pg/dL	4.0–7.4 pmol/L
Pregnant women (4–9 mo gestation)	196–338 pg/dL	3.0–5.2 pmol/L

DESCRIPTION: Unlike the thyroid hormone thyroxine (T_4), most T_3 is converted enzymatically from T_4 in the tissues rather than being produced directly by the thyroid gland (see monograph titled “Thyroxine, Total”). Approximately one-third of T_4 is converted to T_3 . Most T_3 in the serum (99.97%) is bound to thyroxine-binding globulin (TBG), prealbumin, and albumin. The remainder (0.03%) circulates as unbound or free T_3 , which is the physiologically active form. Levels of free T_3 are proportional to levels of total T_3 . The advantage of measuring free T_3 instead of total T_3 is that, unlike total T_3 measurements, free T_3 levels are not affected by fluctuations in TBG levels. T_3 is four to five times more biologically potent than T_4 . This hormone, along with T_4 , is responsible for maintaining a euthyroid state. Free T_3 measurements are rarely required, but they are indicated in the diagnosis of T_3 toxicosis and when certain drugs are being administered that interfere with the conversion of T_4 to T_3 .

INDICATIONS:

- Adjunctive aid to thyroid-stimulating hormone (TSH) and free T_4 assessment
- Assist in the diagnosis of T_3 toxicosis

RESULT:

Increased in:

- High altitude
- Hyperthyroidism
(*Triiodothyronine is produced independently of stimulation by TSH*)
- T_3 toxicosis

Decreased in:

- Hypothyroidism (*Thyroid hormones are not produced in sufficient quantities regardless of TSH levels*)
- Malnutrition (*Related to iodine deficiency; iodine is needed for thyroid hormone synthesis*)
- Nonthyroidal chronic diseases
- Pregnancy (late)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase free T_3 include acetylsalicylic acid, amiodarone, and levothyroxine.

- Drugs that may decrease free T_3 include amiodarone, methimazole, phenytoin, propranolol, and radiographic agents.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess thyroid gland function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include adrenocorticotropic hormone, albumin, ACE, antibodies antithyroglobulin, biopsy thyroid, copper, follicle-stimulating hormone, growth hormone, luteinizing hormone, PTH, protein, RAIU, thyroglobulin, TBil, thyroid scan, TSH, TSI, T_4 , free T_4 , T_3 , and US thyroid.
- ▶ Refer to the Endocrine System table at the back of the book for related tests by body system.

Triiodothyronine, Total

SYNONYM/ACRONYM: T₃.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Immunoassay)

Age	Conventional Units	SI Units (Conventional Units × 0.0154)
1–3 d	100–740 ng/dL	1.54–11.40 nmol/L
1–12 mo	105–245 ng/dL	1.62–3.77 nmol/L
1–5 yr	105–269 ng/dL	1.62–4.14 nmol/L
6–10 yr	94–241 ng/dL	1.45–3.71 nmol/L
16–20 yr	80–210 ng/dL	1.20–3.20 nmol/L
Adult	70–204 ng/dL	1.08–3.14 nmol/L
Pregnant woman (last 4 mo gestation)	116–247 ng/dL	1.79–3.80 nmol/L

DESCRIPTION: Unlike the thyroid hormone thyroxine (T₄), most T₃ is converted enzymatically from T₄ in the tissues rather than being produced directly by the thyroid gland (see monograph titled “Thyroxine, Total”). Approximately one-third of T₄ is converted to T₃. Most T₃ in the serum (99.97%) is bound to thyroxine-binding globulin (TBG), prealbumin, and albumin. The remainder (0.03%) circulates as unbound or free T₃, which is the physiologically active form. Levels of free T₃ are proportional to levels of total T₃. The advantage of measuring free T₃ instead of total T₃ is that, unlike total T₃ measurements, free T₃ levels are not affected by fluctuations in TBG levels. T₃ is four to five times more biologically potent than T₄. This hormone, along with T₄, is responsible for maintaining a euthyroid state.

INDICATIONS:

Adjunctive aid to thyroid-stimulating hormone (TSH) and free T₄ assessment.

RESULT:

Increased in:

- Conditions with increased TBG
- Early thyroid failure
- Hyperthyroidism
(*Triiodothyronine is produced independently of stimulation by TSH*)
- Iodine-deficiency goiter
- Pregnancy
- T₃ toxicosis
- Thyrotoxicosis factitia (*Laboratory tests do not distinguish between endogenous and exogenous sources*)
- Treated hyperthyroidism

Decreased in:

- Acute and subacute nonthyroidal disease (*Pathophysiology is not clear*)

- Conditions with decreased TBG (*TBG is the major transport protein*)
- Hypothyroidism (*Thyroid hormones are not produced in sufficient quantities regardless of TSH levels*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase total T_3 levels include amiodarone, amphetamine, benziodarone, clofibrate, fenopfen, fluorouracil, halofenate, insulin, levothyroxine, methadone, opiates, oral contraceptives, phenytoin, prostaglandins, T_3 , and valproic acid.
- Drugs that may decrease total T_3 levels include acetylsalicylic acid, amiodarone, anabolic steroids, asparaginase, calcium ipodate, carbamazepine, cholestyramine, clomiphene, colestipol, co-trimoxazole, dexamethasone, fenclofenac, furosemide, glucocorticoids, hydrocortisone, interferon alfa-2b, iobenzamic acid, isotretinoin, lithium, methimazole, neomycin, netilmicin, oral contraceptives, penicillamine, phenobarbital, phenylacetic acid derivatives, phenylbutazone, phenytoin, potassium iodide, prednisone, propranolol, propylthiouracil, radiographic agents, sodium ipodate, salicylate, sulfonyleureas, and tyropanoic acid.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess thyroid gland function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor

progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include adrenocorticotropin hormone, albumin, ACE,

antibodies antithyroglobulin, biopsy thyroid, copper, follicle-stimulating hormone, growth hormone, luteinizing hormone, PTH, protein, RAIU, thyroglobulin, TBil, thyroid scan, TSH, TSI, T₄, free T₄, free T₃, and US thyroid. Refer to the Endocrine System table at the back of the book for related tests by body system.

Troponins I and T

SYNONYM/ACRONYM: Cardiac troponin, cardiac troponin I (cTnI), cardiac troponin T (cTnT).

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable. Serial sampling is highly recommended. Care must be taken to use the same type of collection container if serial measurements are to be taken.

REFERENCE VALUE: (Method: Enzyme immunoassay)

Troponin I Less than 0.35 ng/mL
Troponin T Less than 0.20 mcg/L

DESCRIPTION: Troponin is a complex of three contractile proteins that regulate the interaction of actin and myosin. Troponin C is the calcium-binding subunit; it does not have a cardiac muscle-specific subunit. Troponin I and troponin T, however, do have cardiac muscle-specific subunits. They are detectable a few hours to

7 days after the onset of symptoms of myocardial damage. Troponin I is thought to be a more specific marker of cardiac damage than troponin T. Cardiac troponin I begins to rise 2 to 6 hr after myocardial infarction (MI). It has a biphasic peak: It initially peaks at 15 to 24 hr after MI and then exhibits a lower peak after 60 to 80 hr. Cardiac troponin T levels rise 2 to 6 hr after MI and remain elevated. Both proteins return to the reference range 7 days after MI.

Timing for Appearance and Resolution of Serum/Plasma Cardiac Markers in Acute MI

Cardiac Marker	Appearance (hr)	Peak (hr)	Resolution (Days)
AST	6–8	24–48	3–4
CK (Total)	4–6	24	2–3
CK-MB	4–6	15–20	2–3
LDH	12	24–48	10–14
Myoglobin	1–3	4–12	1
Troponin I	2–6	15–20	5–7

INDICATIONS:

- Assist in establishing a diagnosis of MI
- Evaluate myocardial cell damage

RESULT:**Increased in:**

Conditions that result in cardiac tissue damage; troponin is released from damaged tissue into the circulation.

- Acute MI
- Minor myocardial damage
- Myocardial damage after coronary artery bypass graft surgery or percutaneous transluminal coronary angioplasty
- Unstable angina pectoris

Decreased in: N/A

CRITICAL VALUES:

- Troponin I: Greater than 0.5 ng/mL (Initial sample only)

Note and immediately report to the health care provider (HCP) increased results and related symptoms.

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify and monitor cardiac injury.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- ▶ Review the procedure with the patient. Inform the patient that a number of samples will be collected. Collection at time of admission, 2 to 4 hr, 6 to 8 hr, and 12 hr after admission are the minimal recommendations. Additional samples may be requested. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.

- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Increased troponin levels are associated with coronary artery disease (CAD). Nutritional therapy is recommended for individuals identified to be at high risk for developing CAD. If overweight, these patients should be encouraged

to achieve a normal weight. The American Heart Association has Step 1 and Step 2 diets that may be helpful in achieving a goal of lowering total cholesterol and triglyceride levels. The Step 1 diet emphasizes a reduction in foods high in saturated fats and cholesterol. Red meats, eggs, and dairy products are the major sources of saturated fats and cholesterol. If triglycerides are also elevated, patients should be advised to eliminate or reduce alcohol and simple carbohydrates from their diet. The Step 2 diet recommends stricter reductions.

- ◆ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Heart Association (www.americanheart.org).
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any

concerns voiced by the patient or family.

- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include antiarrhythmic drugs, apolipoprotein A and B, AST, ANP, blood gases, blood pool imaging, BNP, calcium, ionized calcium, cholesterol (total, HDL, and LDL), CRP, CT cardiac scoring, CK and isoenzymes, culture viral, echocardiography, echocardiography transesophageal, ECG, exercise stress test, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI chest, MI infarct scan, myocardial perfusion heart scan, myoglobin, pericardial fluid analysis, PET heart, potassium, and triglycerides.
- ◆ Refer to the Cardiovascular System table at the back of the book for related tests by body system.

Tuberculin Skin Tests

SYNONYM/ACRONYM: TB tine test, PPD, Mantoux skin test, QuantiFERON®-TB Gold blood test (QFT-G).

SPECIMEN: Whole Blood (5 mL) collected in a green-top (LiHep or NaHep) tube.

REFERENCE VALUE: (Method: Intradermal skin test, Enzyme Linked Immunosorbent Assay (ELISA) blood test) Negative.

DESCRIPTION: Tuberculin skin tests are done to determine past or present exposure to tuberculosis (TB). The multipuncture or tine test, a screening technique, uses

either purified protein derivative (PPD) of tuberculin or old tuberculin. A positive response at the puncture site indicates cell-mediated immunity to the

organism or a delayed hypersensitivity caused by interaction of the sensitized T lymphocytes. Verification of the patient's positive response to the multipuncture test is done with the more definitive Mantoux test using Aplisol or Tubersol administered by intradermal injection. The Mantoux test is the test of choice in symptomatic patients. It is also used in some settings as a screening test. A negative result is judged if there is no sign of redness or induration at the site of the injection or if the zone of redness and induration is less than 5 mm in diameter. A positive result is evidenced by an area of erythema and induration at the injection site that is greater than 10 mm. A positive result does not distinguish between active and dormant infection. A positive response to the Mantoux test is followed up with chest radiography and bacteriological sputum testing to confirm diagnosis. The QuantiFERON®-TB Gold (QFT-G) blood test was approved by the FDA in 2005 for all applications in which the skin test is used. The blood tests is a two-step procedure in which a sample of whole blood containing T-lymphocytes from the patient is incubated with a reagent cocktail of peptides known to be present in individuals infected by *Mycobacterium tuberculosis*, but not found in the blood of previously vaccinated individuals or individuals who do not have the disease. The blood test offers the advantage of eliminating many of the false reactions encountered with skin testing, only a single patient visit is required, and results can be available within 24 hr.

INDICATIONS:

- Evaluate cough, weight loss, fatigue, hemoptysis, and abnormal x-rays to determine if the cause of symptoms is TB
- Evaluate known or suspected exposure to TB, with or without symptoms, to determine if TB is present
- Evaluate patients with medical conditions placing them at risk for TB (e.g., AIDS, lymphoma, diabetes)
- Screen infants with the tine test at the time of first immunizations to determine TB exposure
- Screen populations at risk for developing TB (e.g., health care providers [HCPs], nursing home residents, correctional facility personnel, prison inmates, and residents of the inner city living in poor hygienic conditions)

RESULT:

Positive findings in:

- **Pulmonary TB**

CRITICAL VALUES:



Note and immediately report to the HCP positive results and related symptoms.

INTERFERING FACTORS:

Skin Tests:

- Drugs such as immunosuppressive agents or steroids can alter results.
- Diseases such as hematological cancers or sarcoidosis can alter results.
- Recent or present bacterial, fungal, or viral infections may affect results. False-positive results may be caused by the presence of non-tuberculous mycobacteria or by serial testing.
- False-negative results can occur if sensitized T cells are temporarily decreased. False-negative results also can occur in the presence of bacterial infections, immunological deficiencies, immunosuppressive agents, live-virus vaccinations

(e.g., measles, mumps, varicella, rubella), malnutrition, old age, overwhelming TB, renal failure, and active viral infections (e.g., chickenpox, measles, mumps).

- Improper storage of the tuberculin solution (e.g., with respect to temperature, exposure to light, and stability on opening) may affect the results.
- Improper technique when performing the intradermal injection (e.g., injecting into subcutaneous tissue) may cause false-negative results.
- Incorrect amount or dilution of antigen injected or delayed injection after drawing the antigen up into the syringe may affect the results.
- Incorrect reading of the measurement of response or timing of the reading may interfere with results.
-  It is not known whether the test has teratogenic effects or reproductive implications; the test should be administered to pregnant women only when clearly indicated.
-  The test should not be administered to a patient with a previously positive tuberculin skin test because of the danger of severe reaction, including vesiculation, ulceration, and necrosis.
- The test does not distinguish between current and past infection.

Blood Test:

- The QFT-G blood test has not been evaluated with patients who have impaired or altered immune function, have or have a high likelihood to develop TB, are younger than 17, are pregnant, or have diseases other than TB.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

Blood and Skin Test:

- Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- Inform the patient that the test is used to indicate exposure to TB.
- Obtain a history of the patient's complaints, including a list of known allergens, especially allergies and sensitivities to latex.
- Obtain a history of the patient's immune and respiratory systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures. Obtain a history of TB or TB exposure, signs and symptoms indicating possible TB, and other skin tests or vaccinations and sensitivities.
- Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- Review the procedure with the patient.

Skin Test:

- Ensure that the patient does not currently have TB and has not had a positive skin test previously before beginning the test. Do not administer the test if the patient has a skin rash or other eruptions at the test site. Inform the patient that the procedure takes approximately 5 min. Address concerns about pain and explain that a moderate amount of pain may be experienced when the intradermal injection is performed.
- Emphasize to the patient that the area should not be scratched or disturbed after the injection and before the reading.

Blood Test:

- Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.

Blood and Skin Test:

- **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

Blood and Skin Test:

- If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient.

Skin Test:

- ▶ Have epinephrine hydrochloride solution (1:1000) available in the event of anaphylaxis.
- ▶ Cleanse the skin site on the lower anterior forearm with alcohol swabs and allow to air-dry.

Multipuncture Test:

- ▶ Remove the cap covering the tines and stretch the forearm skin taut. Firmly press the device into the prepared site, hold it in place for 1 sec, and then remove it. Four punctures should be visible. Record the site, and remind the patient to return in 48 to 72 hr to have the test read. At the time of the reading, use a plastic ruler to measure the diameter of the largest indurated area, making sure the room is sufficiently lighted to perform the reading. A palpable induration greater than or equal to 2 mm at one or more of the punctures indicates a positive test result.

Mantoux (intradermal) Test:

- ▶ Prepare PPD or old tuberculin in a tuberculin syringe with a short, 26-gauge needle attached. Prepare the appropriate dilution and amount for the most commonly used intermediate strength (5 tuberculin units in 0.1 mL) or a first strength usually used for children (1 tuberculin unit in 0.1 mL). Inject the preparation intradermally at the prepared site as soon as it is drawn up into the syringe. When properly injected, a bleb or wheal 6 to 10 mm in diameter is formed within the layers of the skin. Record the site, and remind the patient to return in 48 to 72 hr to have the test read. At the time of the reading, use a plastic ruler to measure the diameter of the largest indurated area, making sure the room is sufficiently lighted to perform the reading. Palpate for thickening of the tissue; a positive result is indicated by a reaction

of 5 mm or more with erythema and edema.

Blood Test:

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate patient tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Counsel the patient, as appropriate, regarding the risk of transmission and proper prophylaxis, and reinforce the importance of strict adherence to the treatment regimen. Inform the patient that positive findings must be reported to local health department officials, who will question him or her regarding other persons who may have been exposed through contact. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Emphasize to the patient who receives skin testing of the need to return and have the test results read within the specified time frame of 48 to 72 hr after injection. Inform the patient that the effects from a positive response at the site can remain for 1 wk. Educate the patient that a positive result may put him or her at risk for infection

related to impaired primary defenses, impaired gas exchange related to decrease in effective lung surface, and intolerance to activity related to an imbalance between oxygen supply and demand. Answer any questions or address any concerns voiced by the patient or family.

- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include alveolar/arterial gradient, angiography pulmonary, biopsy lung, blood gases, bronchoscopy, calcium, carbon dioxide, chest x-ray, complete blood count, WBC count and differential, CT thoracic, culture and smear mycobacteria, culture blood, culture sputum, cytology sputum, eosinophil count, ESR, gallium scan, gram stain, lung perfusion scan, lung ventilation scan, mediastinoscopy, pleural fluid analysis, PFT, and zinc.
- Refer to the Immune and Respiratory System tables at the back of the book for related tests by body system.

Tuning Fork Tests

SYNONYM/ACRONYM: Bing test, Rinne test, Schwabach test, Weber test.

AREA OF APPLICATION: Ears.

CONTRAST: N/A.

DESCRIPTION: These noninvasive assessment procedures are done to distinguish conduction hearing loss from sensorineural hearing loss. They may be performed as part of the physical assessment examination and followed by hearing loss audiometry for confirmation of questionable results. The tuning forks tests described in this monograph are named for the four German otologists who described their use. Tuning forks tests are used less frequently by audiologists in favor of more sophisticated electronic methods, but presentation of the tuning fork test methodology is useful to illustrate the principles involved in electronic test methods.

A tuning fork is a biphonged metallic device that emits a clear tone at a particular pitch when it is set into vibration by holding the stem in the hand and striking one of the prongs or tines against a firm surface. The Bing test samples for conductive hearing loss by intermittently occluding and unblocking the opening of the ear canal while holding a vibrating tuning fork to the mastoid process behind the ear. The occlusion effect is absent in patients with conductive hearing loss and is present in patients with normal hearing or with sensorineural hearing loss. The Rinne test compares the patient's own hearing by bone conduction to his or her hearing by air conduction to determine whether hearing loss,

if detected, is conductive or sensorineural. The Schwabach test compares the patient's level of bone conduction hearing to that of a presumed normal-hearing examiner. The Weber test has been modified by many audiologists for use with electronic equipment. When the test is administered, the patient is asked to tell the examiner the location of the tone heard (left ear, right ear, both ears, or midline) in order to determine whether the hearing loss is conductive, sensorineural, or mixed.

INDICATIONS:

- Evaluate type of hearing loss (conductive or sensorineural)
- Screen for hearing loss as part of a routine physical examination and to determine the need for referral to an audiologist

RESULT:

Normal findings in:

- Normal air and bone conduction in both ears. No evidence of hearing loss.
- Bing test: Pulsating sound that gets louder and softer when the opening to the ear canal is alternately opened and closed. (*Note:* This result, observed in patients with normal hearing, is also observed in patients with sensorineural hearing loss.)
- Rinne test: Longer and louder tone heard by air conduction than by bone conduction. (*Note:* This result, observed in patients with normal hearing, is also observed in patients with sensorineural hearing loss.)
- Schwabach test: Same tone loudness heard equally long by the examiner and the patient.
- Weber test: Same tone loudness heard equally in both ears.

Abnormal findings in:

- Conduction hearing loss:
 - Bing test:* No change in the loudness of the sound.
 - Rinne test:* Tone louder or detected for a longer time than the air-conducted tone
 - Schwabach test:* Prolonged duration of tone when compared to that heard by the examiner
 - Weber test:* Lateralization of tone to one ear indicating loss of hearing on that side (i.e., tone is heard in the poorer ear)
- Sensorineural hearing loss:
 - Bing test:* Pulsating sound that gets louder and softer when the opening to the ear canal is alternately opened and closed
 - Rinne test:* Tone heard louder by air conduction
 - Schwabach test:* Shortened duration of tone when compared to that heard by the examiner.
 - Weber test:* Lateralization of tone to one ear indicating loss of hearing on the other side (i.e., tone is heard in the better ear)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- Poor technique in striking the tuning fork or incorrect placement can result in inaccurate results.
- Inability of the patient to understand how to identify responses or unwillingness of the patient to cooperate during the test can cause inaccurate results.
- Hearing loss in the examiner can affect results in those tests that utilize hearing comparisons between patient and examiner.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the procedure detects hearing loss.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's known or suspected hearing loss, including type and cause; ear conditions with treatment regimens; ear surgery; and other tests and procedures to assess and diagnose auditory deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that no discomfort will be experienced during the test. Inform the patient that a health care provider (HCP) performs the test in a quiet, darkened room, and that to evaluate both ears, the test can take 5 to 10 min.
- ▶ Ensure that the external auditory canal is clear of impacted cerumen.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Seat the patient in a quiet environment positioned such that the patient is comfortable and is facing the examiner. A tuning fork of 1024 Hz is used because it tests within the range of human speech (400 to 5000 Hz).
- ▶ Bing test: Tap the tuning fork handle against the hand to start a light vibration. Hold the handle to the mastoid process behind the ear while alternately opening and closing the ear canal with a finger. Ask the patient to report whether he or she hears a change in loudness or softness in sound. Record the result as a positive Bing if the patient reports a pulsating change in sound. Record as a negative Bing if no change in loudness is detected.
- ▶ Rinne test: Tap the tuning fork handle against the hand to start a light vibration. Have the patient mask the ear not being tested by moving a finger in and out of the ear canal of that ear. Hold the base of the vibrating tuning fork with the thumb and forefinger of the dominant hand and place it in contact with the patient's mastoid process (bone conduction). Ask the patient when the sound is no longer heard. Follow this with placement of the same vibrating tuning fork in front of the ear canal (air conduction) without touching the external part of the ear. Ask the patient which of the two has the loudest or longest tone. Repeat the test in the other ear. Record as Rinne positive if air conduction is heard longer and Rinne negative if bone conduction is heard longer.
- ▶ Schwabach test: Tap the tuning fork handle against the hand to start a light vibration. Hold the base of the tuning fork against one side of the patient's mastoid process and ask if the tone is heard. Have the patient mask the ear not being tested by moving a finger in and out of the ear canal of that ear. The examiner then places the tuning fork against the same side of his or her own mastoid process and listens for the tone. The tuning fork is alternated on the same side between patient and examiner until the sound is no longer heard, noting whether the sound ceased to be heard by both the patient and the examiner at the same point in time. The procedure is repeated on the other ear. If the patient hears the tone for a longer or shorter time, count and note this in seconds.
- ▶ Weber test: Tap the tuning fork handle against the hand to start a light vibration. Hold the base of the vibrating tuning fork with the thumb and forefinger of the dominant hand and place it on the middle of the patient's forehead or at the vertex of the head. Ask the patient to determine if the sound is heard better and longer on one side than the other. Record as Weber right or left. If sound is heard equally, record as Weber negative.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to hearing loss and perceived loss of independence. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services. Provide contact information, if desired, for the American Speech-Language-Hearing Association (www.asha.org).
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. As appropriate, instruct the patient in

the use, cleaning, and storing of a hearing aid. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include audiometry hearing loss, evoked brain potential studies for hearing loss, otoscopy, and spondee speech reception threshold.
- ▶ Refer to the Auditory System table at the back of the book for related tests by body system.

Ultrasound, Arterial Doppler, Carotid Studies

SYNONYM/ACRONYM: Carotid Doppler, carotid ultrasound, arterial ultrasound.

AREA OF APPLICATION: Arteries.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, non-invasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Using the duplex scanning method, carotid US records sound waves to obtain information about the carotid arteries. The amplitude and waveform of the carotid pulse are measured, resulting in a two-dimensional image of the artery. Carotid arterial sites used for the studies include the common carotid, external carotid, and internal carotid. Blood flow direction, velocity, and the presence of flow disturbances can be readily assessed. The sound waves hit the moving red blood cells and are reflected back to the transducer, a flashlight-shaped device, pressed against the skin. The sound that is emitted by the equipment corresponds to the velocity of the blood flow through the vessel. The result is the visualization of the artery to assist in the diagnosis (i.e., presence, amount, location) of plaque causing vessel stenosis or atherosclerotic occlusion affecting the flow of blood to the brain. Depending on the degree of stenosis causing a reduction in vessel diameter, additional testing can be performed to determine the effect of stenosis on the hemodynamic status of the artery.

INDICATIONS:

- Assist in the diagnosis of carotid artery occlusive disease, as evidenced by visualization of blood flow disruption
- Detect irregularities in the structure of the carotid arteries
- Detect plaque or stenosis of the carotid artery, as evidenced by turbulent blood flow or changes in Doppler signals indicating occlusion

RESULT:

Normal findings in:

- Normal blood flow through the carotid arteries with no evidence of occlusion or narrowing

Abnormal findings in:

- Carotid artery occlusive disease (atherosclerosis)
- Plaque or stenosis of carotid artery
- Reduction in vessel diameter of more than 16%, indicating stenosis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair clear imaging:

- Attenuation of the sound waves by bony structures, which can impair clear imaging of the vessels
- Incorrect placement of the transducer over the desired test site
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the arteries in the neck.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium or iodine-based contrast procedures, surgery, or biopsy). There should be 24 hr between administration of barium or iodine contrast medium and this test.
- ▶ Obtain a list of the patient's current medications including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table; other positions may be used during the examination.
- ▶ Expose the neck and drape the patient.
- ▶ Conductive gel is applied to the skin and a Doppler transducer is moved over the skin to obtain images of the area of interest.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his or her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Instruct the patient to continue with diet, fluids, and medications, as directed by the HCP.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address

any concerns voiced by the patient or family.

- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography carotid, angiography coronary, antiarrhythmic drugs, apolipoprotein A & B, AST, blood gases, calcium, cholesterol (total, HDL, LDL), CT angiography, CT cardiac scoring, echocardiography, CRP, CK and isoenzymes, glucose, glycated hemoglobin, Holter monitor, homocysteine, ketones, LDH and isoenzymes, lipoprotein electrophoresis, magnesium, MRI angiography, MRI chest, myocardial infarction scan, myocardial perfusion heart scan, myoglobin, K, PET heart, triglycerides, and troponin.
- ▶ Refer to the Cardiovascular System table in the back of the book for related tests by body system.

Ultrasound, Arterial Doppler, Lower and Upper Extremity Studies

SYNONYM/ACRONYM: Doppler, arterial ultrasound, duplex scan.

AREA OF APPLICATION: Arteries of the lower and upper extremities.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, non-invasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Using the duplex scanning method, arterial leg US records sound waves to obtain information about the arteries of the lower extremities from the common femoral arteries and their branches as they extend into the calf area. The amplitude and waveform of the pulses are measured, resulting in a two-dimensional image of the artery. Blood flow direction, velocity,

and the presence of flow disturbances can be readily assessed, and for diagnostic studies, the technique is done bilaterally. The sound waves hit the moving red blood cells and are reflected back to the transducer, a flashlight-shaped device, pressed against the skin. The sound that is emitted by the equipment corresponds to the velocity of the blood flow through the vessel. The result is the visualization of the artery to assist in the diagnosis (i.e., presence, amount, and location) of plaque causing vessel stenosis or occlusion and to help determine the cause of

claudication. Arterial reconstruction and graft condition and patency can also be evaluated.

In arterial Doppler studies, arteriosclerotic disease of the peripheral vessels can be detected by slowly deflating blood pressure cuffs that are placed on an extremity such as the calf, ankle, or upper extremity. The systolic pressure of the various arteries of the extremities can be measured. The Doppler transducer can detect the first sign of blood flow through the cuffed artery, even the most minimal blood flow, as evidenced by a swishing noise. There is normally a reduction in systolic blood pressure from the arteries of the arms to the arteries of the legs; a reduction exceeding 20 mm Hg is indicative of occlusive disease (deep vein thrombosis) proximal to the area being tested. This procedure may also be used to monitor the patency of a graft, status of previous corrective surgery, vascular status of the blood flow to a transplanted organ, blood flow to a mass, or the extent of vascular trauma.

INDICATIONS:

- Aid in the diagnosis of small or large vessel arterial occlusive disease
- Aid in the diagnosis of spastic arterial disease, such as Raynaud's phenomenon
- Assist in the diagnosis of aneurysm, pseudoaneurysm, hematoma, arteriovenous malformation, or hemangioma
- Assist in the diagnosis of ischemia, arterial calcification, or plaques, as evidenced by visualization of blood flow disruption
- Detect irregularities in the structure of the arteries
- Detect plaque or stenosis of the lower extremity artery, as

evidenced by turbulent blood flow or changes in Doppler signals indicating occlusion

- Determine the patency of a vascular graft, stent, or previous surgery
- Evaluate possible arterial trauma

RESULT:

Normal findings in:

- Normal blood flow through the lower extremity arteries with no evidence of vessel occlusion or narrowing
- Normal arterial systolic and diastolic Doppler signals
- Normal reduction in systolic blood pressure (i.e., less than 20 mm Hg) when compared to a normal extremity
- Normal ankle-to-brachial (AB) arterial blood pressure (ankle pressure divided by brachial pressure; normal AB pressure index is greater than 0.85)

Abnormal findings in:

- AB pressure index less than 0.85, indicating significant arterial occlusive disease within the extremity
- Aneurysm
- Arterial calcification or plaques
- Embolic arterial occlusion
- Graft diameter reduction
- Hemangioma
- Hematoma
- Ischemia
- Large or small vessel occlusive disease
- Pseudoaneurysm
- Reduction in vessel diameter of more than 16%, indicating stenosis
- Spastic arterial occlusive disease, such as Raynaud's phenomenon

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with an open or draining lesion

Factors that may impair the results of the examination:

- Attenuation of the sound waves by bony structures, which can impair clear imaging of the vessels
- Cold extremities, resulting in vasoconstriction, which can cause inaccurate measurements
- Occlusion proximal to the site being studied, which would affect blood flow to the area
- Cigarette smoking, because nicotine can cause constriction of the peripheral vessels
- An abnormally large leg, making direct examination difficult
- Incorrect placement of the transducer over the desired test site
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the peripheral arteries of the lower or upper extremities.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Report the presence of a lesion that is open or draining; maintain clean, dry dressing for the ulcer; protect the limb from trauma.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium

or iodine-based contrast procedures, surgery, or biopsy). There should be 24 hr between administration of barium or iodine contrast medium and this test.

- ▶ Obtain a list of the patient's current medications including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP) specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table; other positions may be used during the examination.
- ▶ Expose the area of interest and drape the patient.
- ▶ Place blood pressure cuffs on the thigh, calf, and ankle.
- ▶ Apply conductive gel to the skin over the area distal to each of the cuffs to promote the passage of sound waves as a Doppler transducer is moved over the skin to obtain images of the area of interest.

- ▶ Inflate the thigh cuff to a level above the patient's systolic pressure found in the normal extremity.
- ▶ Place the Doppler transducer in the gel, distal to the inflated cuff, and slowly release the pressure in the cuff.
- ▶ When the swishing sound of blood flow is heard, record it at the highest point along the artery at which it is audible. The test is repeated at the calf and then the ankle.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Instruct the patient to continue diet, fluids, and medications, as directed by the HCP.
- ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide

teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include alveolar/arterial ratio, angiography pulmonary, ANA, blood gases, complete blood count, platelet count, CT angiography, D-Dimer, FDP, fibrinogen, lung perfusion scan, lung ventilation scan, MRI abdomen, MRI angiography, aPTT, plethysmography, PT/INR, US venous Doppler lower extremities, and venography lower extremity.
- ▶ Refer to the Cardiovascular System table in the back of the book for related tests by body system.

Ultrasound, A-scan

SYNONYM/ACRONYM: None.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: Diagnostic techniques such as A-scan ultrasonography can be used to identify abnormal tissue. The A-scan employs a single-beam, linear sound wave to detect abnormalities by returning an echo when interference disrupts its straight

path. When the sound wave is directed at lens vitreous, the normal homogeneous tissue does not return an echo; an opaque lens with a cataract will produce an echo. The returning waves detected by abnormal tissue are received by a microfilm

that converts the sound energy into electrical impulses that are amplified and displayed on an oscilloscope as an ultrasonogram or echogram. The A-scan echo can be used to indicate the position of the cornea and retina. The A-scan is most commonly used to measure the axial length of the eye. This measurement is used to determine the power requirement for an intraocular lens used to replace the abnormal, opaque lens of the eye removed in cataract surgery. There are two different methods currently in use. The applanation method involves placement of an ultrasound (US) probe directly on the cornea. The immersion technique is more popular because it does not require direct contact and compression of the cornea. The immersion technique protects the cornea by placement of a fluid layer between the eye and the US probe. The accuracy of the immersion technique is thought to be greater than applanation because no corneal compression is caused by the immersion method. Therefore, the measured axial length achieved by immersion is closer to the true axial length of the cornea.

INDICATIONS:

- Determination of power requirement for replacement intraocular lens in cataract surgery.

RESULT:

Normal findings in:

- Normal homogeneous ocular tissue

Abnormal findings in:

- Cataract

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- Inability of the patient to cooperate and remain still during the procedure may interfere with the test results.
- Rubbing or squeezing the eyes may affect results.
- Improper placement of the probe tip to the surface of the eye may produce inaccurate results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure determines the strength of the lens that will be replaced during cataract surgery.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially topical anesthetic eyedrops.
- ◆ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ◆ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Instruct the patient to remove contact lenses or glasses, as appropriate. Instruct the patient regarding the importance of keeping the eyes open for the test.
- ◆ Review the procedure with the patient. Explain that the patient will be requested to fixate the eyes during the procedure. Address concerns

about pain and explain that no discomfort will be experienced during the test but that some discomfort may be experienced after the test when the numbness wears off from the anesthetic drops administered prior to the test. Inform the patient that a health care provider (HCP) performs the test, in a quiet, darkened room, and that evaluation of the eye upon which surgery is to be performed can take up to 10 min.

- ◆ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ There are no food, fluid or medication restrictions, unless by medical direction.

INTRATEST:

- ◆ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ◆ Seat the patient comfortably. Instruct the patient to look straight ahead, keeping the eyes open and unblinking.
- ◆ Instill topical anesthetic in each eye, as ordered, and provide time for it to work. Topical anesthetic drops are placed in the eye with the patient looking up and the solution directed at the six o'clock position of the sclera (white of the eye) near the limbus (grey, semitransparent area of the eyeball where the cornea and sclera meet). Neither the dropper nor the bottle should touch the eyelashes.
- ◆ Ask the patient to place the chin in the chin rest and gently press the forehead against the support bar. When the US probe is properly positioned on the

patient's surgical eye, a reading is automatically taken.

- ◆ Multiple measurements may be taken in order to ensure that a consistent and accurate reading has been achieved. Variability between serial measurements is unavoidable using the applanation technique.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Recognize anxiety related to test results. Encourage the patient to recognize and be supportive of impaired activity related to vision loss, anticipated loss of driving privileges, or the possibility of requiring corrective lenses (self-image). Discuss the implications of test results on the patient's lifestyle. Reassure the patient regarding concerns related to the impending cataract surgery. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Refer to the Ocular System table at the back of the book for related tests by body system.

Ultrasound, Biophysical Profile, Obstetric

SYNONYM/ACRONYM: BPP ultrasound, OB sonography, fetal age sonogram, gestational age sonogram, pregnancy ultrasound, pregnancy echo, pregnant uterus ultrasonography.

AREA OF APPLICATION: Pelvis and abdominal region.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, non-invasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Obstetric US uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin or inserted into the vagina. The waves are bounced back, converted to electrical energy, amplified by the transducer, and displayed on a monitor to visualize the fetus and placenta. This procedure is done by a transabdominal or transvaginal approach, depending on when the procedure is performed (first trimester [transvaginal] vs. second trimester [transabdominal]). It is the safest method of examination to evaluate the uterus and determine fetal size, growth, and position; fetal structural abnormalities; ectopic pregnancy; placenta position and amount of amniotic fluid; and multiple gestation. Obstetric US is used to secure different types of information regarding the fetus, varying with the trimester during which the procedure is done. This procedure may also include a nonstress test (NST)

in combination with Doppler monitoring of amniotic fluid volume, fetal heart, gross fetal movements, fetal muscle tone, and fetal respiratory movements to detect high-risk pregnancy. The procedure is indicated as a guide for amniocentesis, cordocentesis, fetoscopy, aspiration of multiple oocytes for in vitro fertilization, and other intrauterine interventional procedures. Because the pregnant uterus is filled with amniotic fluid, ultrasonography is an ideal method of evaluating the fetus and placenta; it is also the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures.

The biophysical profile (BPP) is a grouping of five antepartum parameters measured to predict fetal wellness. This test grouping is indicated in women with high-risk pregnancies to identify a fetus in distress or in jeopardy of demise. The BPP includes the measurement of fetal heart rate (FHR), fetal breathing movements, fetal body movements, fetal muscle tone, and amniotic fluid volume. Each of the five parameters is

assigned a score of either 0 or 2, allowing a maximum or perfect score of 10. The NST is an external US monitoring of FHR either performed as part of the

BPP or when one or more of the US procedures have abnormal results. The NST is interpreted as either reactive or nonreactive.

BPP Parameter	Normal: Score = 2	Abnormal: Score = 0
Fetal Heart Rate Reactivity	Two or more movement-associated FHR accelerations of 15 or more beats/min above baseline, lasting 15 seconds, in a 20-min interval	One or no movement-associated FHR accelerations of 15 or more beats/min above baseline, in a 20-min interval
Fetal Breathing Movements	One or more breathing movements lasting 20–60 sec in a 30-min interval	Absent or no breathing movements lasting longer than 19 sec in a 30-min interval
Fetal Body Movements	Two or more discrete body or limb movements in a 30-min interval	Less than two discrete body or limb movements in a 30-min interval
Fetal Muscle Tone	One or more episodes of active limb extension and return to flexion (to include opening and closing of hand)	Absent movement, slow extension with partial return to flexion, partial opening of hand
Amniotic Fluid Volume	One or more pockets of fluid that are 2 or more cm in the vertical axis	No pockets of fluid or no pocket measuring at least 2 cm in the vertical axis

A contraction stress test (CST or oxytocin challenge test) may be requested in the event of an abnormal fetal heart rate in the BPP or NST. The CST is used to assess the fetus's ability to tolerate low oxygen levels as experienced during labor contractions. The CST includes external FHR monitoring by US and measurement of oxytocin (pitocin)-induced uterine contractions. Pressure changes during contractions are monitored on an external tocodynamometer. Results of the two tests are interpreted as negative or positive. A negative or normal finding is no late decelerations of FHR during three induced contractions over a 10 min period. A positive or

abnormal finding is identified when frequent contractions of 90 sec or more occur and FHR decelerates beyond the time of the contractions. The amniotic fluid index (AFI) is another application of US used to estimate amniotic fluid volume. The abdomen is divided into four quadrants using the umbilicus to delineate upper and lower halves and linea nigra to delineate the left and right halves. The numbered score is determined by adding the sum in centimeters of fluid in pockets seen in each of the four quadrants. The score is interpreted in relation to gestational age. The median index is considered normal between



8–12 cm. Oligohydramnios (too little amniotic fluid) is associated with an index between 5–6 cm, and polyhydramnios (too much amniotic fluid) with an index between 18–22 cm.

INDICATIONS:

- Detect blighted ovum (missed abortion), as evidenced by empty gestational sac
- Detect fetal death, as evidenced by absence of movement and fetal heart tones
- Detect fetal position before birth, such as breech or transverse presentations
- Detect tubal and other forms of ectopic pregnancy
- Determine and confirm pregnancy or multiple gestation by determining the number of gestational sacs in the first trimester
- Determine cause of bleeding, such as placenta previa or abruptio placentae
- Determine fetal effects of Rh incompatibility due to maternal sensitization
- Determine fetal gestational age by uterine size and measurements of crown-rump length, biparietal diameter, fetal extremities, head, and other parts of the anatomy at key phases of fetal development
- Determine fetal heart and body movements and detect high-risk pregnancy by monitoring fetal heart and respiratory movements in combination with Doppler US or real-time gray-scale scanning
- Determine fetal structural anomalies, usually at the 20th week of gestation or later
- Determine the placental size, location, and site of implantation
- Differentiate a tumor (hydatidiform mole) from a normal pregnancy
- Guide the needle during amniocentesis and fetal transfusion
- Measure fetal gestational age and evaluate umbilical artery, uterine

artery, and fetal aorta by Doppler examination to determine fetal intrauterine growth retardation

- Monitor placental growth and amniotic fluid volume

RESULT:

Normal findings in:

- Normal age, size, viability, position, and functional capacities of the fetus
- Normal placenta size, position, and structure; adequate volume of amniotic fluid
- BPP score of 8–10 is considered normal. Each of the fetal movements evaluated in the BPP is related to oxygen-dependent activities that originate from the central nervous system. Their presence is assumed to indicate normal brain function and absence of systemic hypoxia.

Abnormal findings in:

- Abruptio placentae
- Adnexal torsion
- Cardiac abnormalities
- Ectopic pregnancy
- Fetal death
- Fetal hydrops
- Fetal malpresentation (breech, transverse)
- Hydrocephalus
- Intestinal atresia
- Myelomeningocele
- Multiple pregnancy
- Placenta previa
- Renal or skeletal defects
- BPP score between 4 and 6 is considered equivocal. Gestational age is important in determining intervals for retesting and/or a decision to deliver.

CRITICAL VALUES:

- Abruptio placentae
- Adnexal torsion
- BPP score between 0 and 2 is abnormal and indicates the need for assessment and immediate delivery.
- Ectopic pregnancy
- Fetal death
- Placenta previa

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- ◆ Patients with latex allergy; use of the vaginal probe requires the probe to be covered with a condom-like sac, usually made from latex. Some covers that are latex-free are available.

Factors that may impair clear imaging:

- Incorrect placement of the transducer over the desired test site
- Retained gas or barium from a previous radiological procedure
- Dehydration, which can cause failure to demonstrate the boundaries between organs and tissue structures
- Insufficiently full bladder, which fails to push the bowel from the pelvis and the uterus from the symphysis pubis, thereby prohibiting clear imaging of the pelvic organs in transabdominal imaging
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Improper adjustment of the US equipment to accommodate obese or thin patients, which can cause a poor-quality study
- Patients who are very obese, who may exceed the weight limit for the equipment

Factors that may result in incorrect values:

- Absence of activity in a particular parameter of the BPP may be related to fetal sleep pattern; gestational age less than 33 wk or greater than 42 wk; maternal ingestion of glucose; nicotine; or alcohol; maternal administration of magnesium or medications;

artificial or premature rupture of membranes; and/or labor.

Other considerations:

- Inability of the patient to cooperate or remain still during the procedure because of significant pain or mental status may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure assesses abdomen and pelvic organ function.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ◆ Obtain a history of results of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ◆ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ◆ Endoscopic retrograde cholangiopancreatography and colonoscopy, if ordered, should be scheduled after this procedure.
- ◆ Record the date of the last menstrual period. Obtain a history of menstrual dates, previous pregnancy, and treatment received for high-risk pregnancy.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient the procedure is performed in a US department, usually by a health

care provider (HCP) specializing in this procedure, and takes approximately 30 to 60 min.

- ▶ For the transvaginal approach, inform the patient that a sterile latex- or sheath-covered probe will be inserted into the vagina.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient receiving transabdominal US to drink five to six glasses of fluid 90 min before the procedure, and not to void, because the procedure requires a full bladder. Patients receiving transvaginal US only do not need to have a full bladder.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food or medications restrictions unless by medical direction. The test may be scheduled in relation to mealtime since fetal activity is highest 1 to 3 hr after the mother ingests a meal.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Ensure that the patient drank five to six glasses of fluid and has not voided, if receiving a transabdominal US.
- ▶ Instruct the patient to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table. The right- or left-side-up position may be used to allow gravity to reposition the liver, gas, and fluid to facilitate better organ visualization.
- ▶ Expose the abdominal area and drape the patient.

▶ **Transabdominal approach:** Conductive gel is applied to the skin, and a transducer is moved over the skin while the bladder is distended to obtain images of the area of interest.

▶ **Transvaginal approach:** A lubricated, covered probe is inserted into the vagina and moved to different levels to obtain images.

▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Allow the patient to void, as needed.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Encourage the family to seek appropriate counseling if concerned with pregnancy termination, and to seek genetic counseling if a chromosomal abnormality is determined. Decisions regarding elective abortion should take place in the presence of both parents. Provide a nonjudgmental, nonthreatening atmosphere for discussing the risks and difficulties of delivering and raising a developmentally challenged infant, as well as exploring other options (termination of pregnancy or adoption). It is also important to discuss problems the mother and father may experience (guilt, depression, anger) if fetal abnormalities are detected.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation

to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include α_1 -fetoprotein, amniotic fluid analysis, biopsy chorionic

villus, chromosome analysis, fetal fibronectin, KUB, HCG study, Kleihauer-Betke, L/S ratio, and MRI abdomen.

- Refer to the Reproductive System table at the back of the book for related tests by body system.

Ultrasound, Bladder

SYNONYM/ACRONYM: Bladder sonography.

AREA OF APPLICATION: Bladder.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, noninvasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Bladder US evaluates disorders of the bladder, such as masses or lesions. Bladder position, structure, and size are examined with the use of high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin. Methods for imaging include the transrectal, transurethral, and transvaginal approach. The waves are bounced back, converted to electrical energy, amplified by the transducer, and displayed on a monitor to evaluate the structure and position of the contents of the bladder. The examination is helpful for monitoring patient response to therapy for bladder disease. Bladder images can be included in ultrasonography of the kidneys, ureters, bladder, urethra,

and gonads in diagnosing renal/neurological disorders. Bladder US may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures.

INDICATIONS:

- Assess residual urine after voiding to diagnose urinary tract obstruction causing overdistention
- Detect tumor of the bladder wall or pelvis, as evidenced by distorted position or changes in bladder contour
- Determine end-stage malignancy of the bladder caused by extension of a primary tumor of the ovary or other pelvic organ
- Evaluate the cause of urinary tract infection, urine retention, and flank pain
- Evaluate hematuria, urinary frequency, dysuria, and suprapubic pain
- Measure urinary bladder volume by transurethral or transvaginal approach


RESULT:**Normal findings in:**

- Normal size, position, and contour of the bladder

Abnormal findings in:

- Bladder diverticulum
- Cyst
- Cystitis
- Malignancy of the bladder
- Tumor
- Ureterocele
- Urinary tract obstruction

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

-  Patients with latex allergy; use of the vaginal probe requires the probe to be covered with a condom-like sac, usually made from latex. Some covers that are latex-free are available.

Factors that may impair clear imaging:

- Incorrect placement of the transducer over the desired test site
- Retained gas or barium from a previous radiological procedure
- Dehydration, which can cause failure to demonstrate the boundaries between organs and tissue structures
- Insufficiently full bladder, which fails to push the bowel from the pelvis and the uterus from the symphysis pubis, thereby prohibiting clear imaging of the pelvic organs in transabdominal imaging
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow pretesting preparations may cause the procedure to be canceled or repeated.

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the bladder and pelvic organs.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary, reproductive, and gastrointestinal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ▶ Endoscopic retrograde cholangiopancreatography, colonoscopy, and computed tomography of the abdomen, if ordered, should be scheduled after this procedure.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure. Explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP), with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is

important in providing psychological support before, during, and after the procedure.

- ▶ Inform the patient for the transvaginal approach, that a sterile latex- or sheath-covered probe will be inserted into the vagina.
- ▶ Instruct the patient receiving transabdominal US to drink five to six glasses of fluid 90 min before the procedure, and not to void, because the procedure requires a full bladder. Patients receiving transvaginal US only do not need to have a full bladder.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Ensure that the patient drank five to six glasses of fluid and has not voided, if receiving a transabdominal US.
- ▶ Instruct the patient to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table. The right- or left-side-up positions may be used to allow gravity to reposition the liver, gas, and fluid to facilitate better organ visualization.
- ▶ Expose the abdominal area and drape the patient.
- ▶ **Transabdominal approach:** Conductive gel is applied to the skin, and a transducer is moved over the skin while the

bladder is distended to obtain images of the area of interest.

- ▶ **Transvaginal approach:** A covered and lubricated probe is inserted into the vagina and moved to different levels during scanning.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his or her breath.
- ▶ If the patient is to be examined for residual urine volume, ask the patient to empty the bladder; repeat the procedure and calculate the volume.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Allow the patient to void, as needed.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include bladder cancer markers urine, CT pelvis, cystoscopy, IVP, KUB study, and MRI pelvis.
- ▶ Refer to the Genitourinary, Reproductive, and Gastrointestinal System tables in the back of the book for related tests by body system.

Ultrasound, Breast

SYNONYM/ACRONYM: Mammographic ultrasound.

AREA OF APPLICATION: Breast.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, non-invasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. When used in conjunction with mammography and clinical examination, breast US is indispensable in the diagnosis and management of benign and malignant processes. Both breasts are usually examined during this procedure. The examination uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin. The waves are bounced back, converted to electrical energy, amplified by the transducer, and displayed on a monitor to determine the presence of palpable and nonpalpable masses and their size and structure. This procedure is useful in patients with an abnormal mass on a mammogram because it can determine whether the abnormality is cystic or solid; that is, it can differentiate between a palpable, fluid-filled cyst and a palpable, solid breast lesion (benign or malignant). It is especially useful in patients with dense breast tissue and in those with silicone prostheses, because the US beam easily penetrates in these situations, allowing routine examination that cannot be

performed with x-ray mammography. The procedure can be done as an adjunct to mammography, or it can be done in place of mammography in patients who refuse x-ray exposure or those in whom it is contraindicated (e.g., pregnant women, women less than 25 y.o.). The procedure is indicated as a guide for biopsy and other interventional procedures and as a means of monitoring disease progression or the effects of treatment.

INDICATIONS:

- Detect very small tumors in combination with mammography for diagnostic validation
- Determine the presence of nonpalpable abnormalities viewed on mammography of dense breast tissue, and monitor changes in these abnormalities
- Differentiate among types of breast masses (e.g., cyst, solid tumor, other lesions) in dense breast tissue
- Evaluate palpable masses in young (less than age 25), pregnant, and lactating patients
- Guide interventional procedures such as cyst aspiration, large-needle core biopsy, fine-needle aspiration biopsy, abscess drainage, presurgical localization, and galactography
- Identify an abscess in a patient with mastitis

RESULT:**Normal findings in:**

- Normal subcutaneous, mammary, and retromammary layers of tissue in both breasts; no evidence of pathological lesions (cyst or tumor) in either breast

Abnormal findings in:

- Abscess
- Breast solid tumor, lesions
- Cancer (ductal carcinoma, infiltrating lobular carcinoma, medullary carcinoma, tubular carcinoma, and papillary carcinoma)
- Cystic breast disease
- Fibroadenoma
- Focal fibrosis
- Galactocele
- Hamartoma (fibroadenolipoma)
- Hematoma
- Papilloma
- Phyllodes tumor
- Radial scar

CRITICAL VALUES: N/A**INTERFERING FACTORS:****Factors that may impair clear imaging:**

- Incorrect placement of the transducer over the desired test site
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Excessively large breasts
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.

- ▶ Inform the patient that the procedure assesses the breast.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of results of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient not to apply lotions, bath powder, or other substances to the chest and breast area before the examination.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has not applied lotions, bath powder, or other substances to the chest and breast area before the examination.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to change into the gown and robe provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.

- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table. The right- and left-side-up positions are also used during the scan to facilitate better organ visualization.
- ▶ Expose the breast area and drape the patient.
- ▶ Conductive gel is applied to the skin and a transducer is moved over the skin to obtain images of the area of interest.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Recognize anxiety related to test results. Discuss the implications of

abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include biopsy breast, CEA and cancer antigens, chest x-ray, CT thorax, mammogram, MRI breast, and stereotactic biopsy breast.
- ▶ Refer to the Reproductive System table at the back of the book for related tests by body system.

Ultrasound, Kidney

SYNONYM/ACRONYM: Renal ultrasound, renal sonography.

AREA OF APPLICATION: Kidney.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, noninvasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Renal US is used to evaluate renal system disorders. It is valuable for determining the internal components of renal

masses (solid versus cystic) and for evaluating other renal diseases, renal parenchyma, perirenal tissues, and obstruction. US uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin. The waves are bounced back, converted to electrical energy,

amplified by the transducer, and displayed on a monitor to evaluate the structure, size, and position of the kidney. Renal US can be performed on the same day as a radionuclide scan or other radiological procedure, and is especially valuable in patients who are in renal failure, have hypersensitivity to contrast medium, have a kidney that did not visualize on intravenous pyelography (IVP), or are pregnant. It does not rely on renal function or the injection of contrast medium to obtain a diagnosis. The procedure is indicated for evaluation after a kidney transplant and is used as a guide for biopsy and other interventional procedures, abscess drainage, and nephrostomy tube placement. Renal US may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures.

INDICATIONS:

- Aid in the diagnosis of the effect of chronic glomerulonephritis and end-stage chronic renal failure on the kidneys (e.g., decrease in size)
- Detect an accumulation of fluid in the kidney caused by backflow of urine, hemorrhage, or perirenal fluid
- Detect masses and differentiate between cysts or solid tumors, as evidenced by specific waveform patterns or absence of sound waves
- Determine the presence and location of renal or ureteral calculi and obstruction
- Determine the size, shape, and position of a nonfunctioning kidney to identify the cause
- Evaluate or plan therapy for renal tumors
- Evaluate renal transplantation for changes in kidney size
- Locate the site of and guide percutaneous renal biopsy, aspiration needle insertion, or nephrostomy tube insertion
- Monitor kidney development in children when renal disease has been diagnosed
- Provide the location and size of renal masses in patients who are unable to undergo IVP because of poor renal function or an allergy to iodinated contrast medium

RESULT:

Normal findings in:

- Absence of calculi, cysts, hydronephrosis, obstruction, or tumor
- Normal size, position, and shape of the kidneys and associated structures

Abnormal findings in:

- Acute glomerulonephritis
- Acute pyelonephritis
- Congenital anomalies, such as absent, horseshoe, ectopic, or duplicated kidney
- Hydronephrosis
- Obstruction of ureters
- Perirenal abscess or hematoma
- Polycystic kidney
- Rejection of renal transplant
- Renal calculi
- Renal cysts, hypertrophy, or tumors
- Ureteral obstruction

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair clear imaging:

- Attenuation of the sound waves by the ribs, which can impair clear imaging of the kidney
- Incorrect placement of the transducer over the desired test site

- Retained gas or barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses kidney function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ▶ Endoscopic retrograde cholangiopancreatography, colonoscopy, and computed tomography of the abdomen, if ordered, should be scheduled after this procedure.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure. Explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort. Inform the

patient that the procedure is performed in a US department, usually by a health care provider (HCP), with support staff, and takes approximately 30 to 60 min.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table. The right- or left-side-up positions may be used to allow gravity to reposition the liver, gas, and fluid to facilitate better organ visualization.
- ▶ Expose the abdominal and kidney area and drape the patient.
- ▶ Conductive gel is applied to the skin, and a transducer is moved over the skin to obtain images of the area of interest.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his or her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography renal, anti-glomerular basement membrane antibody, biopsy kidney, BUN, calculus kidney stone panel, CT abdomen, creatinine, creatinine clearance, cytology urine, erythropoietin, group A streptococcal screen, IVP, KUB study, MRI abdomen, renogram, retrograde ureteropyelography, and UA.
- ▶ Refer to the Genitourinary System table at the back of the book for related tests by system.

Ultrasound, Liver and Biliary System

SYNONYM/ACRONYM: Gallbladder ultrasound, liver ultrasound, hepatobiliary sonography.

AREA OF APPLICATION: Liver, gallbladder, bile ducts.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, non-invasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Hepatobiliary US uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin. The waves are bounced back, converted to electrical energy, amplified by the transducer, and displayed on a monitor to evaluate the structure, size, and position of the liver and gallbladder in the right upper quadrant (RUQ) of the abdomen. The gallbladder and biliary system collect, store, concentrate, and transport bile to the intestines to aid in digestion. This procedure allows

visualization of the gallbladder and bile ducts when the patient may have impaired liver function, and it is especially helpful when done on patients in whom gallstones cannot be visualized with oral or IV radiological studies. Liver US can be done in combination with a nuclear scan to obtain information about liver function and density differences in the liver. The procedure is indicated as a guide for biopsy and other interventional procedures. Hepatobiliary US may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures.

INDICATIONS:

- Detect cysts, polyps, hematoma, abscesses, hemangioma, adenoma, metastatic disease, hepatitis, or solid tumor of the liver or gallbladder, as evidenced by echoes specific to tissue density and sharply or poorly defined masses
- Detect gallstones or inflammation when oral cholecystography is inconclusive
- Detect hepatic lesions, as evidenced by density differences and echo-pattern changes
- Determine the cause of unexplained hepatomegaly and abnormal liver function tests
- Determine cause of unexplained RUQ pain
- Determine patency and diameter of the hepatic duct for dilation or obstruction
- Differentiate between obstructive and nonobstructive jaundice by determining the cause
- Evaluate response to therapy for tumor, as evidenced by a decrease in size of the organ
- Guide biopsy or tube placement
- Guide catheter placement into the gallbladder for stone dissolution and gallbladder fragmentation

RESULT:**Normal findings in:**

- Normal size, position, and shape of the liver and gallbladder, as well as patency of the cystic and common bile ducts

Abnormal findings in:

- Biliary or hepatic duct obstruction/dilation
- Cirrhosis
- Gallbladder inflammation, stones, carcinoma, polyps
- Hematoma or trauma
- Hepatic tumors, metastasis, cysts, hemangioma, hepatitis
- Hepatocellular disease, adenoma
- Hepatomegaly

- Intrahepatic abscess
- Subphrenic abscesses

CRITICAL VALUES: N/A**INTERFERING FACTORS:****Factors that may impair clear imaging:**

- Attenuation of the sound waves by the ribs, which can impair clear imaging of the right lobe of the liver
- Incorrect placement of the transducer over the desired test site
- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and can produce unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

Other considerations:

- Failure to follow dietary restrictions may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the liver and biliary function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hepatobiliary and gastrointestinal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ◆ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ◆ Endoscopic retrograde cholangiopancreatography, colonoscopy, and computed tomography of the abdomen, if ordered, should be scheduled after this procedure.
- ◆ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ◆ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department, usually by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- ◆ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ◆ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ◆ The patient should fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.

INTRATEST:

- ◆ Ensure that food and fluids have been restricted for at least 8 hr prior to the procedure.
- ◆ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ◆ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ◆ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.
- ◆ Place the patient in the supine position on an exam table. The right- or left-side-up positions may be used to

allow gravity to reposition the liver, gas, and fluid to facilitate better organ visualization.

- ◆ Expose the abdominal area and drape the patient.
- ◆ Conductive gel is applied to the skin, and a transducer is moved over the skin to obtain images of the area of interest.
- ◆ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his or her breath.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ When the study is completed, remove the gel from the skin.
- ◆ Instruct the patient to resume usual diet and fluids, as directed by the HCP.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include ALP, ALT, AST, bilirubin, biopsy liver, cholangiography, colonoscopy, CT abdomen, endoscopy, ERCP, GGT, haptoglobin, hepatitis A, B, C (antigens and/or antibodies), hepatobiliary scan, laparoscopy abdominal, MRI abdomen, and radiofrequency ablation liver.
- ◆ Refer to the Hepatobiliary and Gastrointestinal System tables at the back of the book for related tests by body system.

Ultrasound, Lymph Nodes and Retroperitoneum

SYNONYM/ACRONYM: Lymph node sonography.

AREA OF APPLICATION: Abdomen, pelvis, and retroperitoneum.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, noninvasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Lymph node US uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin. The waves are bounced back, converted to electrical energy, amplified by the transducer, and displayed on a monitor to evaluate the structure, size, and position of the lymph nodes to examine the retroperitoneum and surrounding tissues. This procedure is used for the evaluation of retroperitoneal pathology, usually lymph node enlargement. US is the preferred diagnostic method because this area is inaccessible to conventional radiography in diagnosing lymphadenopathy, although it can be used in combination with lymphangiography, magnetic resonance imaging (MRI), and computed tomography (CT) to confirm the diagnosis. The procedure may be used for monitoring the effect of radiation or chemotherapy on the lymph nodes. Lymph node US may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is

sufficient to make the diagnosis without any further imaging procedures.

INDICATIONS:

- Detect lymphoma
- Determine the location of enlarged nodes to plan radiation and other therapy
- Determine the size or enlargement of aortic and iliac lymph nodes
- Evaluate the effects of medical, radiation, or surgical therapy on the size of nodes or tumors, as evidenced by shrinkage or continued presence of the mass or nodes

RESULT:

Normal findings in:

- Normal retroperitoneal and intrapelvic node size of 1.5 cm in diameter

Abnormal findings in:

- Infection or abscess
- Lymphoma
- Retroperitoneal tumor

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair clear imaging:

- Incorrect placement of the transducer over the desired test site
- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate

cleansing or failure to restrict food intake before the study

- Retained barium from a previous radiological procedure
- Dehydration, which can cause failure to demonstrate the boundaries between organs and tissue structures
- Insufficiently full bladder, which fails to push the bowel from the pelvis and the uterus from the symphysis pubis, thereby prohibiting clear imaging of the pelvic organs in transabdominal imaging
- Metallic objects (e.g., jewelry, or body rings) within the examination field which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary/fluid instructions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the lymph nodes and retroperitoneum.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary, reproductive, immune, and GI systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There

should be 24 hr between administration of barium and this test.

- ▶ Endoscopic retrograde cholangiopancreatograph, colonoscopy, and CT of the abdomen, if ordered, should be scheduled after this procedure.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Inform the patient that transabdominal US requires a full bladder. Protocols may vary from facility to facility.
- ▶ Instruct the patient to drink five to six glasses of fluid 90 min before the procedure, and not to void before the procedure.

INTRATEST:

- ▶ Ensure that food and fluids have been restricted for at least 8 hr prior to the procedure.
- ▶ Ensure that the patient drank five to six glasses of fluid 90 min before the procedure, and remind him or her not to void before the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.

- ◆ Place the patient in the supine position on an exam table; other positions may be used during the examination.
- ◆ Expose the abdominal area and drape the patient.
- ◆ Conductive gel is applied to the skin, and a transducer is moved over the skin while the bladder is distended to obtain images of the area of interest.
- ◆ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his or her breath.

POST-TEST:

- ◆ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Allow the patient to void, as needed.
- ◆ When the study is completed, remove the gel from the skin.
- ◆ Instruct the patient to resume usual diet and fluids, as directed by the HCP.
- ◆ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include angiography of the abdomen, biopsy bone marrow, biopsy lymph nodes, complete blood count, complete blood count, hemoglobin, complete blood count, RBC count, complete blood count, RBC morphology and inclusions, CT abdomen, CT colonoscopy, ESR, gallium scan, KUB study, laparoscopy abdominal, lymphangiogram, and MRI abdomen.
- ◆ Refer to the Genitourinary, Reproductive, Immune, and Gastrointestinal System tables at the back of the book for related tests by body system.

Ultrasound, Pancreas

SYNONYM/ACRONYM: Pancreatic ultrasonography.

AREA OF APPLICATION: Pancreas and upper abdomen.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, noninvasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Pancreatic US uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin. The waves are bounced

back, converted to electrical energy, amplified by the transducer, and displayed on a monitor to determine the size, shape, and position of the pancreas; determine the presence of masses or other abnormalities of the pancreas; and examine the surrounding viscera. The procedure is indicated as a guide for biopsy, aspiration, and other interventional

procedures. Pancreatic US may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures; however, it is usually done in combination with computed tomography (CT) or magnetic resonance imaging of the pancreas.

INDICATIONS:

- Detect anatomic abnormalities as a consequence of pancreatitis
- Detect pancreatic cancer, as evidenced by a poorly defined mass or a mass in the head of the pancreas that obstructs the pancreatic duct
- Detect pancreatitis, as evidenced by pancreatic enlargement with increased echoes
- Detect pseudocysts, as evidenced by a well-defined mass with absence of echoes from the interior
- Monitor therapeutic response to tumor treatment
- Provide guidance for percutaneous aspiration and fine-needle biopsy of the pancreas

RESULT:

Normal findings in:

- Normal size, position, contour, and texture of the pancreas

Abnormal findings in:

- Acute pancreatitis
- Calculi
- Pancreatic duct obstruction
- Pancreatic tumor
- Pseudocysts

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair clear imaging:

- Attenuation of the sound waves by the ribs, which can impair clear imaging of the pancreas

- Incorrect placement of the transducer over the desired test site
- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary and fluids restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses pancreatic function.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's endocrine and GI systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ♦ Endoscopic retrograde cholangiopancreatography, colonoscopy, and CT of the abdomen, if ordered, should be scheduled after this procedure.
- ♦ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department, usually by a health care provider (HCP) specializing in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that food and fluids have been restricted for at least 8 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table. The right- or left-side-up position may be used to allow gravity to reposition the liver, gas, and fluid to facilitate better organ visualization.

- ▶ Expose the abdominal area and drape the patient.
- ▶ Conductive gel is applied to the skin, and a transducer is moved over the skin to obtain images of the area of interest.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his or her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Instruct the patient to resume usual diet and fluids, as directed by the HCP.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amylase, CEA and cancer antigens, ERCP, CT abdomen and pancreas, C peptide, KUB study, laparoscopy abdominal, lipase, MRI abdomen and pancreas, and peritoneal fluid analysis.
- ▶ Refer to the Endocrine and Gastrointestinal System tables at the back of the book for related tests by body system.

Ultrasound, Pelvis (Gynecologic, Nonobstetric)

SYNONYM/ACRONYM: Pelvic sonography, lower abdominal ultrasound, pelvic gynecologic (GYN) sonogram.

AREA OF APPLICATION: Pelvis and appendix region.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, non-invasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Gynecologic US uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin or inserted into the vagina. The waves are bounced back, converted to electrical energy, amplified by the transducer, and displayed on a monitor in order to:

Determine the presence, size, and structure of masses and cysts; and determine the position of an intrauterine contraceptive device (IUD)

Evaluate postmenopausal bleeding

Examine other abnormalities of the uterus, ovaries, fallopian tubes, and vagina

This procedure is done by a transabdominal or transvaginal approach. The transabdominal approach provides a view of the pelvic organs posterior to the bladder. It requires a full bladder, thereby allowing a window for transmission of the US waves, pushing the uterus away from the pubic symphysis, pushing the bowel out of the pelvis, and acting as a reference for comparison in the evaluation of the internal structures of a mass or cyst being

examined. The transvaginal approach focuses on the female reproductive organs and is often used to monitor ovulation over a period of days in patients undergoing fertility assessment. This approach is also used in obese patients or in patients with retroversion of the uterus because the sound waves are better able to reach the organ from the vaginal site. Transvaginal images are significantly more accurate compared to anterior transabdominal images in identifying paracervical, endometrial, and ovarian pathology, and the transvaginal approach does not require a full bladder. The procedure is indicated as a guide for biopsy and other interventional procedures. Pelvic US may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures.

INDICATIONS:

- Detect and monitor the treatment of pelvic inflammatory disease (PID) when done in combination with other laboratory tests
- Detect bleeding into the pelvis resulting from trauma to the area or ascites associated with tumor metastasis

- Detect masses in the pelvis and differentiate them from cysts or solid tumors, as evidenced by differences in sound-wave patterns
- Detect pelvic abscess or peritonitis caused by a ruptured appendix or diverticulitis
- Detect pregnancy, including ectopic pregnancy
- Detect the presence of ovarian cysts and malignancy and determine the type, if possible, as evidenced by size, outline, and change in position of other pelvic organs
- Evaluate the effectiveness of tumor therapy, as evidenced by a reduction in mass size
- Evaluate suspected fibroid tumor or bladder tumor
- Evaluate the thickness of the uterine wall
- Monitor placement and location of an IUD
- Monitor follicular size associated with fertility studies or to remove follicles for in vitro transplantation

RESULT:

Normal findings in:

- Normal size, position, location, and structure of pelvic organs (e.g., uterus, ovaries, fallopian tubes, vagina); IUD properly positioned within the uterine cavity

Abnormal findings in:

- Endometrioma
- Fibroids (leiomyoma)
- Nonovarian cyst
- Ovarian cysts
- Pelvic abscess
- Peritonitis
- PID
- Uterine tumor or adnexal tumor

CRITICAL VALUES:


- Abscess
- Adnexal torsion
- Appendicitis
- Ectopic pregnancy

- Infection
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with latex allergy; use of the vaginal probe requires the probe to be covered with a condom-like sac, usually made from latex. Some covers that are latex-free are available.

Factors that may impair clear imaging:

- Incorrect placement of the transducer over the desired test site
- Gas or feces in the gastrointestinal (GI) tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Dehydration, which can cause failure to demonstrate the boundaries between organs and tissue structures
- Insufficiently full bladder, which fails to push the bowel from the pelvis and the uterus from the symphysis pubis, thereby prohibiting clear imaging of the pelvic organs in transabdominal imaging
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary/fluid instructions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses pelvic organ function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of results of the patient's genitourinary, reproductive, and GI systems and symptoms, as well as results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ▶ Endoscopic retrograde cholangiopancreatography, colonoscopy, and computed tomography (CT) of the abdomen, if ordered, should be scheduled after this procedure.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ Instruct the patient that a latex or sterile sheath-covered probe will be inserted into the vagina for the transvaginal approach.

- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ Instruct the patient receiving transabdominal US to drink three to five glasses of fluid 90 min before the exam and not to void, because the procedure requires a full bladder. Patients receiving transvaginal US only do not need to have a full bladder.

INTRATEST:

- ▶ Ensure that food and fluids have been restricted for at least 8 hr prior to the procedure.
- ▶ Ensure the patient receiving transabdominal US drank three to five glasses of fluid 90 min before the exam.
- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to change into the gown, robe, and foot coverings provided. Remind her not to void before the procedure. Patients receiving transvaginal US do not need to have a full bladder.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table. The right- or left-side-up positions may be used to allow gravity to reposition the liver, gas, and fluid to facilitate better organ visualization.
- ▶ Expose the abdominal and pelvic area and drape the patient.
- ▶ **Transabdominal approach:** Conductive gel is applied to the skin, and a transducer is moved over the skin while the bladder is distended to obtain images of the area of interest.
- ▶ **Transvaginal approach:** A covered and lubricated probe is inserted into the vagina and moved to different levels. Images are obtained and recorded.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.

- ▶ Allow the patient to void, as needed.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Instruct the patient to resume usual diet and fluids, as directed by the HCP.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.
- ▶ Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be

needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CEA and cancer antigens, colposcopy, CT abdomen, hysterosalpingography, laparoscopy gynecologic, KUB study, and MRI abdomen, PAP smear, and PET pelvis.
- ▶ Refer to the Genitourinary, Reproductive, and Gastrointestinal System tables at the back of the book for related tests by body system.

Ultrasound, Prostate (Transrectal)

SYNONYM/ACRONYM: Prostate sonography.

AREA OF APPLICATION: Prostate, seminal vesicles.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, noninvasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Prostate US is used for the evaluation of disorders of the prostate, especially in response to an elevated concentration of prostate-specific antigen on a blood test and as a complement to a digital rectal examination. It uses high-frequency waves of various intensities delivered by a transducer, a candle-shaped device, which is lubricated, sheathed with a condom, and inserted a few inches into the rectum. The waves are bounced back, converted to

electrical energy, amplified by the transducer, and displayed on a monitor to evaluate the structure, size, and position of the contents of the prostate (e.g., masses), as well as other prostate pathology. It aids in the diagnosis of prostatic cancer by evaluating palpable nodules and is useful as a guide to biopsy. This procedure can evaluate prostate tissue, the seminal vesicles, and surrounding perirectal tissue. It can also be used to stage carcinoma and to assist in radiation seed placement. The examination is helpful in monitoring patient response to therapy for prostatic disease. Micturition disorders can also be evaluated by this procedure. Prostate US

may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures.

INDICATIONS:

- Aid in the diagnosis of micturition disorders
- Aid in prostate cancer diagnosis
- Assess prostatic calcifications
- Assist in guided needle biopsy of a suspected tumor
- Assist in radiation seed placement
- Determine prostatic cancer staging
- Detect prostatitis

RESULT:

Normal findings in:

- Normal size, consistency, and contour of the prostate gland


Abnormal findings in:

- Benign prostatic hypertrophy or hyperplasia
- Micturition disorders
- Perirectal abscess
- Perirectal tumor
- Prostate abscess
- Prostate cancer
- Prostatitis
- Rectal tumor
- Seminal vesicle tumor

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with latex allergy; use of the rectal probe requires the probe to be covered with a condom, usually made from latex. Some covers that are latex-free are available.

Factors that may impair clear imaging:

- Attenuation of the sound waves by the pelvic bones, which can

impair clear imaging of the prostate

- Incorrect placement of the transducer over the desired test site
- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow pretesting preparations may cause the procedure to be canceled or repeated.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the prostate.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of results of the patient's genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ▶ Colonoscopy and computed tomography (CT) of the abdomen, if ordered, should be scheduled after this procedure.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.

- Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- Inform the patient that a sterile latex- or sheath-covered probe will be inserted into the rectum.
- Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- Observe standard precautions, and follow the general guidelines in Appendix A.
- Place the patient on the examining table on his left side with his knees bent toward the chest; other positions may be used during the examination.
- Expose the rectal area and drape the patient.
- Cover the rectal probe with a lubricated condom and insert it into the rectum. Inform the patient that he may feel slight pressure as the transducer is inserted. Water may be introduced through the sheath surrounding the transducer.
- Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his breath.

POST-TEST:

- A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- When the study is completed, remove the gel from the skin.
- Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include biopsy prostate, CT pelvis, cystoscopy, cystourethrography voiding, IVP, KUB study, MRI pelvis, proctosigmoidoscopy, PSA, renogram, retrograde ureteropyelography, and semen analysis.
- Refer to the Genitourinary System table at the back of the book for related tests by body system.

Ultrasound, Scrotal

SYNONYM/ACRONYM: Scrotal sonography, ultrasound of the testes, testicular ultrasound.

AREA OF APPLICATION: Scrotum.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, noninvasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Scrotal US is used for the evaluation of disorders of the scrotum. It is valuable in determining the internal components of masses (solid versus cystic) and for the evaluation of the testicle, extratesticular and intrascrotal tissues, benign and malignant tumors, and other scrotal pathology. It uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, which is pressed against the skin. The waves are bounced back, converted to electrical energy, amplified by the transducer, and displayed on a monitor to evaluate the structure, size, and position of the contents of the scrotum. Scrotal US can be performed before or after a radionuclide scan for further clarification of a testicular mass. Extratesticular lesions such as hydrocele, hemocele (blood in the scrotum), and pyocele (pus in the scrotum) can be identified, as can cryptorchidism (undescended testicles). Scrotal US may be the diagnostic examination of choice because no radiation

is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures.

INDICATIONS:

- Aid in the diagnosis of a chronic inflammatory condition such as epididymitis
- Aid in the diagnosis of a mass and differentiate between a cyst and a solid tumor, as evidenced by specific waveform patterns or the absence of sound waves, respectively
- Aid in the diagnosis of scrotal or testicular size, abnormality, or pathology
- Aid in the diagnosis of testicular torsion and associated testicular infarction
- Assist guided needle biopsy of a suspected testicle tumor
- Determine the cause of chronic scrotal swelling or pain
- Determine the presence of a hydrocele, pyocele, spermatocele, or hernia before surgery
- Evaluate the effectiveness of treatment for testicular infections
- Locate an undescended testicle

RESULT:

Normal findings in:

- Normal size, position, and shape of the scrotum and structure of the testes

Abnormal findings in:

- Abscess
- Epididymal cyst
- Epididymitis
- Hematoma
- Hydrocele
- Infarction
- Microlithiasis
- Orchitis
- Pyocele
- Scrotal hernia
- Spermatocele
- Torsion
- Tumor, benign or malignant
- Tunica albuginea cyst
- Undescended testicle (cryptorchidism)
- Varicocele

CRITICAL VALUES:

- Testicular torsion

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:**Factors that may impair clear imaging:**

- Incorrect placement of the transducer over the desired test site
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the scrotum.
- ▶ Obtain a history of the patient's complaints, including a list of known

allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's genitourinary and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ▶ Colonoscopy and computed tomography (CT) of the abdomen, if ordered, should be scheduled after this procedure.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department, by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table; other

positions may be used during the examination.

- ▶ Expose the abdomen/pelvic area and drape the patient.
- ▶ Lift the penis upward and gently tape it to the lower part of the abdomen. Elevate the scrotum with a rolled towel or sponge for immobilization. Display particular sensitivity toward the patient regarding any embarrassment he may feel during this part of the procedure.
- ▶ Conductive gel is applied to the skin, and a transducer is moved over the skin to obtain images of the area of interest.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the study is completed, remove the gel from the skin.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include AFP, CT pelvis, KUB study, MRI pelvis, and semen analysis.
- ▶ Refer to the Genitourinary and Reproductive System tables at the back of the book for related tests by body system.

Ultrasound, Spleen

SYNONYM/ACRONYM: Spleen ultrasonography.

AREA OF APPLICATION: Spleen/left upper quadrant.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, non-invasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Spleen US uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin. The waves are bounced back, converted to electrical energy, amplified by the transducer, and

displayed on a monitor to evaluate the structure, size, and position of the spleen. This test is valuable for determining the internal components of splenic masses (solid versus cystic) and evaluating other splenic pathology, splenic trauma, and left upper quadrant perisplenic tissues. It can be performed to supplement a radionuclide scan or computed tomography (CT). It is especially valuable in patients

who are in renal failure, are hypersensitive to contrast medium, or are pregnant, because it does not rely on adequate renal function or the injection of contrast medium to obtain a diagnosis. The procedure may also be used as a guide for biopsy, other interventional procedures, and abscess drainage. Spleen US may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures.

INDICATIONS:

- Detect the presence of a subphrenic abscess after splenectomy
- Detect splenic masses; differentiate between cysts or solid tumors (in combination with CT), as evidenced by specific waveform patterns or absence of sound waves, respectively; and determine whether they are intrasplenic or extrasplenic
- Determine late-stage sickle cell disease, as evidenced by decreased spleen size and presence of echoes
- Determine the presence of splenomegaly, and assess the size and volume of the spleen in these cases, as evidenced by increased echoes and visibility of the spleen
- Differentiate spleen trauma from blood or fluid accumulation between the splenic capsule and parenchyma
- Evaluate the effect of medical or surgical therapy on the progression or resolution of splenic disease
- Evaluate the extent of abdominal trauma and spleen involvement, including enlargement or rupture, after a recent trauma
- Evaluate the spleen before splenectomy performed for thrombocytopenic purpura

RESULT:

Normal findings in:

- Normal size, position, and contour of the spleen and associated structures

Abnormal findings in:

- Abscesses
- Accessory or ectopic spleen
- Infection
- Lymphatic disease; lymph node enlargement
- Splenic calcifications
- Splenic masses, tumors, cysts, or infarction
- Splenic trauma
- Splenomegaly

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair clear imaging:

- Attenuation of the sound waves by the ribs and an aerated left lung, which can impair clear imaging of the spleen
- Masses near the testing site, which can displace the spleen and cause inaccurate results if confused with splenomegaly
- Dehydration, which can cause failure to demonstrate the boundaries between organs and tissue structures
- Incorrect placement of the transducer over the desired test site
- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and can produce unclear images

Other considerations:

- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses splenic function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's hematopoietic, immune, and gastrointestinal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ▶ Endoscopic retrograde cholangiopancreatography, colonoscopy, and CT of the abdomen, if ordered, should be scheduled after this procedure.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects in the area to be examined.
- ▶ The patient should fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that food and fluids have been restricted for at least 8 hr prior to the procedure.
- ▶ Ensure that the patient has removed all external metallic objects in the area prior to the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table. The right- or left-side-up position may be used to allow gravity to reposition the liver, gas, and fluid to facilitate better organ visualization.
- ▶ Expose the abdominal area and drape the patient.
- ▶ Conductive gel is applied to the skin, and a transducer is moved over the skin to obtain images of the area of interest.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his or her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Instruct the patient to resume usual diet and fluids, as directed by the HCP.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in

therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

▶ Related tests include angiography abdomen, biopsy bone marrow, complete blood count, platelet count,

complete blood count, WBC count and differential, CT abdomen, KUB study, liver and spleen scan, MRI abdomen, sickle cell screen, and WBC scan.

▶ Refer to the Hematopoietic, Immune, and Gastrointestinal System tables at the back of the book for related tests by body system.

Ultrasound, Thyroid and Parathyroid

SYNONYM/ACRONYM: Thyroid sonography, parathyroid sonography, thyroid echo.

AREA OF APPLICATION: Thyroid, parathyroid, and anterior neck region.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, noninvasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Thyroid and parathyroid US uses high-frequency waves of various intensities delivered by a transducer, a flashlight-shaped device, pressed against the skin. The waves are bounced back, converted to electrical energy, amplified by the transducer, and displayed on a monitor to determine the position, size, shape, weight, and presence of masses of the thyroid gland; enlargement of the parathyroid glands; and other abnormalities of the thyroid and parathyroid glands and surrounding tissues. The primary purpose of this procedure is to determine whether a nodule is a fluid-filled cyst (usually benign) or a solid tumor (possibly malignant). This procedure is useful in evaluating the glands' response to medical treatment or assessing the remaining tissue after surgical resection.

The procedure may be indicated as a guide for biopsy, aspiration, or other interventional procedures. Thyroid and parathyroid US may be the diagnostic examination of choice because no radiation is used and, in most cases, the accuracy is sufficient to make the diagnosis without any further imaging procedures; it is clearly the procedure of choice when examining the glands of pregnant patients. This procedure is usually done in combination with nuclear medicine imaging procedures and computed tomography (CT) of the neck. Despite the advantages of the procedure, in some cases it may not detect small nodules and lesions (less than 1 cm), leading to false-negative findings.

INDICATIONS:

- Assist in determining the presence of a tumor, as evidenced by an irregular border and shadowing at the distal edge, peripheral echoes, or high- and low-amplitude echoes, depending on the density

of the tumor mass; and diagnosing tumor type (e.g., benign, adenoma, carcinoma)

- Assist in diagnosing the presence of a cyst, as evidenced by a smoothly outlined, echo-free amplitude except at the far borders of the mass
- Assist in diagnosis in the presence of a parathyroid enlargement indicating a tumor or hyperplasia, as evidenced by an echo pattern of lower amplitude than that for a thyroid tumor
- Determine the need for surgical biopsy of a tumor or fine-needle biopsy of a cyst
- Differentiate among a nodule, solid tumor, or fluid-filled cyst
- Evaluate the effect of a therapeutic regimen for a thyroid mass or Graves' disease by determining the size and weight of the gland
- Evaluate thyroid abnormalities during pregnancy

RESULT:

Normal findings in:

- Normal size, position, contour, and structure of the thyroid and parathyroid glands with uniform echo patterns throughout the glands; no evidence of tumor cysts or nodules in the glands

Abnormal findings in:

- Glandular enlargement
- Goiter
- Graves' disease
- Parathyroid tumor or hyperplasia
- Thyroid cysts
- Thyroid tumors (benign or malignant)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair clear imaging:

- Attenuation of the sound waves by the ribs, which can impair clear imaging of the parathyroid

- Incorrect placement of the transducer over the desired test site
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Nodules less than 1 cm in diameter may not be detected.
- Nonthyroid cysts may appear the same as thyroid cysts.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses thyroid and parathyroid function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium and this test.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP), with support staff, and takes approximately 30 to 60 min.

- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table; other positions may be used during the examination.
- ▶ Expose the neck and chest area and drape the patient.
- ▶ Hyperextend the neck, and place a pillow under the patient's shoulders to maintain a comfortable position. (An alternative method of imaging includes the use of a bag filled with water or gel placed over the neck area.)
- ▶ Conductive gel is applied to the skin, and a transducer is moved over the skin to obtain images of the area of interest.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the

patient to inhale deeply and hold his or her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ When the study is completed, remove the gel from the skin.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include antibodies antithyroglobulin, biopsy thyroid, chest x-ray, CT thorax, MRI chest, PTH, parathyroid scan, radioactive iodine uptake, thyroid-binding inhibitory immunoglobulin, thyroglobulin, thyroid scan, TSH, thyroxine free, thyroxine total, triiodothyronine free, and triiodothyronine total.
- ▶ Refer to the Endocrine System table in the back of the book for related tests by body system.

Ultrasound, Venous Doppler, Extremity Studies

U

SYNONYM/ACRONYM: Venous ultrasound, venous sonogram, venous duplex.

AREA OF APPLICATION: Veins of the upper and lower extremities.

CONTRAST: Done without contrast.

DESCRIPTION: Ultrasound (US) procedures are diagnostic, non-invasive, and relatively inexpensive. They take a short time to complete, do not use radiation, and cause no harm to the patient. Peripheral venous Doppler US records sound waves to obtain information about the patency of the venous vasculature in the upper and lower extremities to identify narrowing or occlusions of the veins or arteries. In venous Doppler studies, the Doppler identifies moving red blood cells (RBCs) within the vein. The US beam is directed at the vein and through the Doppler transducer while the RBCs reflect the beam back to the transducer. The reflected sound waves or echoes are transformed by a computer into scans, graphs, or audible sounds. Blood flow direction, velocity, and the presence of flow disturbances can be readily assessed. The velocity of the blood flow is transformed as a “swishing” noise, audible through the audio speaker. If the vein is occluded, no swishing sound is heard.

For diagnostic studies, the procedure is done bilaterally. The sound emitted by the equipment corresponds to the velocity of the blood flow through the vessel occurring with spontaneous respirations. Changes in these sounds during respirations indicate the possibility of abnormal venous flow secondary to occlusive disease; the absence of sound indicates complete obstruction. Compression with a transducer augments a vessel for evaluation of thrombosis. Noncompressibility of the vessel indicates a thrombosis. Plethysmography may be performed to determine the filling time of calf veins to diagnose thrombotic disorder of a major vein and to identify incompetent

valves in the venous system. An additional method used to evaluate incompetent valves is the Valsalva technique combined with venous duplex imaging.

INDICATIONS:

- Aid in the diagnosis of venous occlusion secondary to thrombosis or thrombophlebitis
- Aid in the diagnosis of superficial thrombosis or deep vein thrombosis (DVT) leading to venous occlusion or obstruction, as evidenced by absence of venous flow, especially upon augmentation of the extremity; variations in flow during respirations; or failure of the veins to compress completely when the extremity is compressed
- Detect chronic venous insufficiency, as evidenced by reverse blood flow indicating incompetent valves
- Determine if further diagnostic procedures are needed to make or confirm a diagnosis
- Determine the source of emboli when pulmonary embolism is suspected or diagnosed
- Determine venous damage after trauma to the site
- Differentiate between primary and secondary varicose veins
- Evaluate the patency of the venous system in patients with a swollen, painful leg
- Monitor the effectiveness of therapeutic interventions

RESULT:

Normal findings in:

- Normal Doppler venous signal that occurs spontaneously with the patient’s respiration
- Normal blood flow through the veins of the extremities with no evidence of vessel occlusion

Abnormal findings in:

- Chronic venous insufficiency
- Primary varicose veins

- Recannulization in the area of an old thrombus
- Secondary varicose veins
- Superficial thrombosis or DVT
- Venous narrowing or occlusion secondary to thrombosis or thrombophlebitis
- Venous trauma

CRITICAL VALUES:

- DVT

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients with an open or draining lesion

Factors that may impair clear imaging:

- Attenuation of the sound waves by bony structures, which can impair clear imaging of the vessels
- Cigarette smoking, because nicotine can cause constriction of the peripheral vessels
- Incorrect placement of the transducer over the desired test site
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Cold extremities, resulting in vasoconstriction that can cause inaccurate measurements
- Occlusion proximal to the site being studied, which would affect blood flow to the area
- An abnormally large or swollen leg, making sonic penetration difficult
- Incorrect positioning of the patient, which may produce poor visualization of the area to be examined

Other considerations:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the procedure assesses the veins.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Report the presence of a lesion that is open or draining; maintain clean, dry dressing for the ulcer; protect the limb from trauma.
- ♦ Note any recent procedures that can interfere with test results (i.e., barium procedures, surgery, or biopsy). There should be 24 hr between administration of barium- or iodine-based contrast medium and this test.
- ♦ Endoscopic retrograde cholangiopancreatography, colonoscopy, and computed tomography of the abdomen, if ordered, should be scheduled after this procedure.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Address concerns about pain related to the procedure and explain that some pain may be experienced during the test, and there may be moments of discomfort. Inform the patient that the procedure is performed in a US department by a health care provider (HCP) who specializes in this procedure, with support staff, and takes approximately 30 to 60 min.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ Instruct the patient to remove jewelry and other metallic objects from the area to be examined.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ Ensure that the patient has removed all external metallic objects from the area to be examined prior to the procedure.

- ▶ Instruct the patient to void and change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient in the supine position on an exam table; other positions may be used during the examination.
- ▶ Expose the area of interest and drape the patient.
- ▶ Conductive gel is applied to the skin, and a transducer is moved over the area to obtain images of the area of interest. Waveforms are visualized and recorded with variations in respirations. Images with and without compression are performed proximally or distally to an obstruction to obtain information about a venous occlusion or obstruction. The procedure can be performed for both arms and legs to obtain bilateral blood flow determination.
- ▶ Do not place the transducer on an ulcer site when there is evidence of venous stasis or ulcer.
- ▶ Ask the patient to breathe normally during the examination. If necessary for better organ visualization, ask the patient to inhale deeply and hold his or her breath.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
 - ▶ When the study is completed, remove the gel from the skin.
- ▶ Instruct the patient to continue diet, fluids, and medications, as directed by the HCP.
 - ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
 - ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
 - ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include alveolar/arterial ratio, angiography pulmonary, blood gases, complete blood count, platelet count, CT angiography, D-dimer, FDP, fibrinogen, lung perfusion scan, lung ventilation scan, MRI abdomen, MRI angiography, aPTT, plethysmography, PT/INR, US arterial doppler lower extremity studies, and venography lower extremities.
- ▶ Refer to the Cardiovascular System table in the back of the book for related tests by body system.

Upper Gastrointestinal and Small Bowel Series

SYNONYM/ACRONYM: Stomach series, gastric radiography, small bowel study, upper GI series, UGI.

AREA OF APPLICATION: Esophagus, stomach, and small intestine.

CONTRAST: Barium sulfate.

DESCRIPTION: The upper gastrointestinal (GI) series is a radiological examination of the esophagus, stomach, and small intestine after ingestion of barium sulfate, which is a milkshake-like, radiopaque substance. A combination of x-ray and fluoroscopy techniques is used to record the study. Air may be instilled to provide double contrast and better visualization of the lumen of the esophagus, stomach, and duodenum. If perforation or obstruction is suspected, a water-soluble iodinated contrast medium is used. This test is especially useful in the evaluation of patients experiencing dysphagia, regurgitation, gastroesophageal reflux (GER), epigastric pain, hematemesis, melena, and unexplained weight loss. This test is also used to evaluate the results of gastric surgery, especially when an anastomotic leak is suspected. When a small bowel series is included, the test detects disorders of the jejunum and ileum. The patient's position is changed during the examination to allow visualization of the various structures and their function. The images are visualized on a fluoroscopic screen, recorded, and stored electronically or on x-ray film for review by a physician. Drugs such as glucagon may be given during an upper GI series to relax the GI tract; drugs such as metoclopramide (Reglan) may be given to accelerate the passage of the barium through the stomach and small intestine.

When the small bowel series is performed separately, the patient may be asked to drink several glasses of barium, or enteroclysis may be used to instill the barium. With entero-

clysis, a catheter is passed through the nose or mouth and advanced past the pylorus and into the duodenum. Barium, followed by methylcellulose solution, is instilled via the catheter directly into the small bowel.

INDICATIONS:

- Determine the cause of regurgitation or epigastric pain
- Determine the presence of neoplasms, ulcers, diverticula, obstruction, foreign body, and hiatal hernia
- Evaluate suspected GER, inflammatory process, congenital anomaly, motility disorder, or structural change
- Evaluate unexplained weight loss or anemia
- Identify and locate the origin of hematemesis

RESULT:

Normal findings in:

- Normal size, shape, position, and functioning of the esophagus, stomach, and small bowel

Abnormal findings in:

- Achalasia
- Cancer of the esophagus
- Chalasis
- Congenital abnormalities
- Duodenal cancer, diverticula, and ulcers
- Esophageal diverticula, motility disorders, ulcers, varices, and inflammation
- Gastric cancer, tumors, and ulcers
- Gastritis
- Hiatal hernia
- Perforation of the esophagus, stomach, or small bowel
- Polyps
- Small bowel tumors
- Strictures

CRITICAL VALUES:

- Foreign body
- Perforated bowel
- Tumor with significant mass effect

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:***This procedure is contraindicated for:***

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Patients with an intestinal obstruction
- Patients suspected of having upper GI perforation, in whom barium should not be used

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Patients with swallowing problems may aspirate the barium, which could interfere with the procedure and cause patient complications.
- Possible constipation or partial bowel obstruction caused by retained barium in the small bowel or colon may affect test results.
- This procedure should be done after a kidney x-ray (IV pyelography) or computed tomography (CT) of the abdomen or pelvis.
- Risks associated with radiation overexposure can result from

frequent x-ray procedures.

Personnel in the room with the patient should wear a lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the upper GI system and/or small bowel.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that this procedure is performed before a barium swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain and explain to the patient that there may be moments of discomfort and some pain experienced during the procedure. Inform the patient that the procedure is usually performed in a radiology department by a HCP with support staff, and takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important

in providing psychological support before, during, and after the procedure.

- ▶ Explain to the patient that he or she will be asked to drink a milkshake-like solution that has an unpleasant chalky taste.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary and fluid restrictions for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.

Upper Gastrointestinal Series:

- ▶ Place the patient on the x-ray table in a supine position, or ask the patient to stand in front of an fluoroscopy screen.
- ▶ Instruct the patient to take several swallows of the barium mixture through a straw while images are taken of the pharyngeal motion. An effervescent agent may also be administered to introduce air into the stomach.

Small Bowel Series:

- ▶ If the small bowel is to be examined after the upper GI series, instruct the patient to drink an additional glass of barium while the small intestine is observed for passage of barium. Images are taken at 30- to 60-min intervals until the barium reaches the ileocecal valve. This process can last up to 5 hr, with follow-up images taken at 24 hr.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.

- ▶ Instruct the patient to resume usual diet and fluids, as directed by the HCP.
- ▶ Monitor for reaction to iodinated contrast medium, including rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting, if iodine is used.

- ▶ Instruct the patient to take a mild laxative and increase fluid intake (four glasses) to aid in the elimination of barium, unless contraindicated.

- ▶ Inform the patient that his or her stool will be white or light in color for 2 to 3 days. If the patient is unable to eliminate the barium, or if the stool does not return to normal color, the patient should notify the HCP.

- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independence and fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include barium enema, barium swallow, capsule endoscopy, CT abdomen, endoscopic retrograde cholangiopancreatography, esophageal manometry, fecal analysis, gastric acid stimulation test, gastric emptying scan, gastrin stimulation test, gastroesophageal reflux scan, H. pylori, KUB study, MRI abdomen, and US pelvis.

- ▶ Refer to the Gastrointestinal System table at the back of the book for related tests by body system.

Urea Breath Test

SYNONYM/ACRONYM: PY test, C-14 Urea Breath Test, Breath Test, Pylori Breath Test, UBT.

AREA OF APPLICATION: Stomach.

CONTRAST: Radioactive C-14 urea in capsule form.

DESCRIPTION: The C-14 urea breathe test (UBT) is used to assist in the diagnosis of *Helicobacter pylori* (*H. pylori*) infection. *H. pylori* is a bacteria that can infect the stomach lining. *H. pylori* has been implicated as the cause of many gastrointestinal conditions, including the development of duodenal and gastric ulcers. The UBT is a simple, noninvasive diagnostic nuclear medicine procedure that requires the patient to swallow a small amount of radiopharmaceutical C-14-labeled urea in a capsule with lukewarm water. In the presence of urease, an enzyme secreted by *H. pylori* in the gut, the urea in the capsule is broken down into nitrogen and C-14-labeled carbon dioxide (CO₂). The labeled CO₂ is absorbed through the stomach lining into the blood and excreted by the lungs. Breath samples are collected and trapped in a mylar balloon. The C-14 urea is counted and quantitated with a liquid scintillation counter. The UBT can also be used to indicate the elimination of *H. pylori* infection after treatment with antibiotics. Other tests used to detect the presence of *H. pylori* include a blood *H. pylori* antibody test, a stool antigen test, and stomach biopsy.

INDICATIONS:

- Aid in detection of the presence of *H. pylori* infection in the stomach
- Monitor eradication of *H. pylori* infection following treatment regimen
- Evaluation of new-onset dyspepsia

RESULT:

Normal findings in:

- Negative for *H. pylori*: Less than 50 dpm (disintegrations per minute)

Abnormal findings in:

- Indeterminate for *H. pylori*: 50–199 dpm
- Positive for *H. pylori*: Greater than 200 dpm

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure outweigh the risks to the fetus and the mother
- Patients who have taken antibiotics, Pepto-Bismol, or bismuth in the past 30 days
- Patients who have taken sucralfate in the past 14 days
- Patients who have used a proton pump inhibitor within the past 14 days

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Failure to follow dietary restrictions and other pretesting preparations may cause the procedure to be canceled or repeated.
- Patients who have had resective gastric surgery have the potential for resultant bacterial overgrowth (non-*H. pylori* urease), which can cause a false-positive result.
- Achlorhydria can cause a false-positive result.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses gastrointestinal (GI) infection.
- ▶ Obtain a history of the patient's GI system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in premenopausal women.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Address concerns about pain and explain that there should be no discomfort during the procedure. Inform the patient that the procedure is done in the nuclear medicine department by technologists and support staff and usually takes approximately 30 to 60 min.
- ▶ *Sensitivity to social and cultural issues* is important in providing psychological support before, during, and after the procedure.

- ▶ Instruct the patient to fast, restrict fluids, and, by medical direction, withhold medication for 6 hr prior to the procedure. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure the patient has complied with dietary and medication restrictions and pretesting preparations; assure that food, fluids and medications have been restricted for at least 6 hr prior to the procedure.
- ▶ Instruct the patient to blow into a balloon prior to the start of the procedure to collect a sample of breath.
- ▶ Instruct the patient to swallow the C-14 capsule directly from a cup followed by 20 mL of lukewarm water. Provide an additional 20 mL of lukewarm water for the patient to drink at 3 min after the dose.
- ▶ Breath samples are taken at different periods of time by instructing the patient to take in a deep breath and hold it for approximately 5–10 sec before exhaling through a straw into a mylar balloon.
- ▶ Samples are counted on a liquid scintillation counter (LSC) and recorded in dpm.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet and medication, as directed by the HCP.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 12 to 24 hr to eliminate the radionuclide from the body.
- ▶ If a woman who is breastfeeding must have a breathe test, she should not breastfeed the infant until the radionuclide has been eliminated. She should be instructed to express the milk and discard it during a 3-day period to prevent cessation of milk production.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further

testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of the procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for change in therapy. Evaluate test results in relation to

the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include EGD, gastric emptying scan, *H. pylori* antibody, KUB study, and UGI.
- ▶ See the Gastrointestinal System table at the end of the book for related tests by body system.

Urea Nitrogen, Blood

SYNONYM/ACRONYM: BUN.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 0.357)
Newborn–3 yr	5–17 mg/dL	1.8–6.0 mmol/L
4–13 yr	7–17 mg/dL	2.5–6.0 mmol/L
14 yr–adult	8–21 mg/dL	2.9–7.5 mmol/L
Adult older than 90 yr	10–31 mg/dL	3.6–11.1 mmol/L

DESCRIPTION: Urea is a nonprotein nitrogen compound formed in the liver from ammonia as an end product of protein metabolism. Urea diffuses freely into extracellular and intracellular fluid and is ultimately excreted by the kidneys. Blood urea nitrogen (BUN) levels reflect the balance between the production and excretion of urea. BUN and creatinine values are commonly evaluated together. The normal BUN/creatinine ratio is 15:1 to 24:1. (e.g., if a patient has a BUN of 15 mg/dL, the creatinine should be approximately 0.6 to 1.0 mg/dL). BUN is used in the

following calculation to estimate serum osmolality:

$$(2 \times \text{Na}^+) + (\text{glucose}/18) + (\text{BUN}/2.8).$$

INDICATIONS:

- Assess nutritional support
- Evaluate hemodialysis therapy
- Evaluate hydration
- Evaluate liver function
- Evaluate patients with lymphoma after chemotherapy (tumor lysis)
- Evaluate renal function
- Monitor the effects of drugs known to be nephrotoxic or hepatotoxic

RESULT:**Increased in:**

- Acute renal failure (*Related to decreased renal excretion*)
- Chronic glomerulonephritis (*Related to decreased renal excretion*)
- Congestive heart failure (*Related to decreased blood flow to the kidneys, decreased renal excretion, and accumulation in circulating blood*)
- Decreased renal perfusion (*Reflects decreased renal excretion and increased blood levels*)
- Diabetes (*Related to decreased renal excretion*)
- Excessive protein ingestion (*Related to increased protein metabolism*)
- Gastrointestinal (GI) bleeding (*Excessive blood protein in the GI tract and increased protein metabolism*)
- Hyperalbuminemia (*Related to increased protein metabolism*)
- Hypovolemia (*Related to decreased blood flow to the kidneys, decreased renal excretion, and accumulation in circulating blood*)
- Ketoacidosis (*Dehydration from ketoacidosis correlates with decreased renal excretion of urea nitrogen*)
- Muscle wasting from starvation (*Related to increased protein metabolism*)
- Neoplasms (*Related to increased protein metabolism or to decreased renal excretion*)
- Nephrotoxic agents (*Related to decreased renal excretion and accumulation in circulating blood*)
- Pyelonephritis (*Related to decreased renal excretion*)
- Shock (*Related to decreased blood flow to the kidneys, decreased renal excretion, and accumulation in circulating blood*)

- Urinary tract obstruction (*Related to decreased renal excretion and accumulation in circulating blood*)

Decreased in:

- Inadequate dietary protein (*Urea nitrogen is a by-product of protein metabolism; less available protein is reflected in decreased BUN levels*)
- Low-protein/high-carbohydrate diet (*Urea nitrogen is a by-product of protein metabolism; less available protein is reflected in decreased BUN levels*)
- Malabsorption syndromes (*Urea nitrogen is a by-product of protein metabolism; less available protein is reflected in decreased BUN levels*)
- Pregnancy
- Severe liver disease (*BUN is synthesized in the liver so liver damage results in decreased levels*)

CRITICAL VALUES: 

Greater than 100 mg/dL (non-dialysis patients)

Note and immediately report to the health care provider (HCP) any critically increased or decreased values and related symptoms. A patient with a grossly elevated BUN may have signs and symptoms including acidemia, agitation, confusion, fatigue, nausea, vomiting, and coma. Possible interventions include treatment of the cause, administration of IV bicarbonate, a low-protein diet, hemodialysis, and caution with respect to prescribing and continuing nephrotoxic medications.

INTERFERING FACTORS:

- Drugs, substances, and vitamins that may increase BUN levels include acetaminophen, alanine, aldatense, alkaline antacids, amphotericin B, antimony compounds, arsenicals, bacitracin, bismuth subsalicylate, capreomycin, carbenoxolone, carbutamide,

- cephalosporins, chloral hydrate, chloramphenicol, chlorthalidone, colistimethate, colistin, cotrimoxazole, dexamethasone, dextran, diclofenac, doxycycline, ethylene glycol, gentamicin, guanethidine, guanoxan, ibuprofen, ifosfamide, ipodate, kanamycin, mephenesin, metolazone, mitomycin, neomycin, phosphorus, plicamycin, tertatolol, tetracycline, triamterene, triethylenemelamine, viomycin, and vitamin D.
- Drugs that may decrease BUN levels include acetohydroxamic acid, chloramphenicol, fluorides, paramethasone, phenothiazine, and streptomycin.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess renal function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.

- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Monitor intake and output for fluid imbalance in renal dysfunction and dehydration.
- ▶ **Nutritional considerations:** Nitrogen balance is commonly used as a nutritional assessment tool to indicate protein change. In healthy individuals, protein anabolism and catabolism are in equilibrium. During various disease states, nutritional intake decreases, resulting in a negative balance. During recovery from illness and with proper nutritional support, the nitrogen balance becomes positive. BUN is an important analyte to measure during administration of total parenteral nutrition (TPN). Educate the patient, as appropriate, in dietary adjustments required to maintain proper nitrogen balance. Inform the patient that the requesting HCP may prescribe TPN as part of the treatment plan.
- ▶ **Nutritional considerations:** An elevated BUN can be caused by a high-protein diet or dehydration. Unless medically restricted, a healthy diet consisting of the five food groups of the food pyramid should be consumed daily. Water consumption should include six to eight 8-oz glasses of water per day, or water consumption equivalent to half of the body's weight in fluid ounces (32 fl oz = 1 qt; 34 fl oz = 1 L).
- ▶ Recognize anxiety related to test results. Discuss the implications of

abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include anion gap, antibiotic drugs, biopsy kidney, calcium, calculus kidney stone panel, CT spleen, creatinine, creatinine clearance, cytology urine, cystoscopy, electrolytes, gallium scan, glucose, glycated hemoglobin, 5-HIAA, IVP, ketones, magnesium, microalbumin, osmolality, oxalate, phosphorus, protein total and fractions, renogram, US kidney, UA, urea nitrogen urine, and uric acid.
- ▶ Refer to the Genitourinary System table at the back of the book for related tests by body system.

Urea Nitrogen, Urine

SYNONYM/ACRONYM: N/A.

SPECIMEN: Urine (5 mL) from an unpreserved random or timed specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Spectrophotometry)

Conventional Units	SI Units (Conventional Units × 35.7)
12–20 g/24 hr	428–714 mmol/24 hr

DESCRIPTION: Urea is a nonprotein nitrogen compound formed in the liver from ammonia as an end product of protein metabolism. Urea diffuses freely into extracellular and intracellular fluid and is ultimately excreted by the kidneys. Urine urea nitrogen levels reflect the balance between the production and excretion of urea.

liver disease, will have on the kidneys

RESULT:

Increased in:

- Diabetes (**Related to decreased renal excretion**)
- Hyperthyroidism
- Increased dietary protein (**Related to increased protein metabolism**)
- Postoperative period

Decreased in:

- Liver disease (**BUN is synthesized in the liver so liver damage results in decreased levels**)

INDICATIONS:

- Evaluate renal disease
- Predict the impact that other conditions, such as diabetes and

- Low-protein/high-carbohydrate diet (**Urea nitrogen is a by-product of protein metabolism; less available protein is reflected in decreased BUN levels**)
- Normal-growing pediatric patients (**Increased demand for protein; less available protein is reflected in decreased BUN levels**)
- Pregnancy (**Increased demand for protein; less available protein is reflected in decreased BUN levels**)
- Renal disease (**Related to decreased renal excretion**)
- Toxemia (**Related to hypertension and decreased renal excretion**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase urine urea nitrogen levels include alanine and glycine.
- Drugs that may decrease urine urea nitrogen levels include furosemide, growth hormone, insulin, and testosterone.
- All urine voided for the timed collection period must be included in the collection or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.

**NURSING IMPLICATIONS
AND PROCEDURE**

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess renal function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ Usually a 24-hour time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hour period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Random Specimen (collect in early morning):

Clean-catch specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.

Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.

Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.

If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.

At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.

Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any medications that can affect test results.

General:

Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

Nutritional considerations: An elevated BUN can be caused by a high-protein diet or dehydration. Unless medically restricted, a healthy diet consisting of the five food groups of the food pyramid should be consumed daily. Water consumption should include six to eight 8-ounce glasses of water per day, or water consumption equivalent to half of the body's weight in fluid ounces (32 fl oz = 1 qt; 34 fl oz = 1 L).

Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.

Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

Related tests include anion gap, antibiotic drugs, biopsy kidney, BUN, calcium, calculus kidney stone panel, CT spleen, creatinine, creatinine clearance, cytology urine, cystoscopy, electrolytes, gallium scan, glucose, glycosylated hemoglobin, 5-HIAA, IVP, ketones, magnesium, microalbumin, osmolality, oxalate, phosphorus, protein total and fractions, renogram, US kidney, UA, blood urea nitrogen, and uric acid.

Refer to the Genitourinary and Hepatobiliary System tables at the back of the book for related tests by body system.

Urethrography, Retrograde

SYNONYM/ACRONYM: N/A.

AREA OF APPLICATION: Urethra.

CONTRAST: Radiopaque contrast medium.

DESCRIPTION: Retrograde urethrography is performed almost exclusively in male patients. It uses contrast medium, either injected or instilled via a catheter into the urethra, to visualize the membranous, bulbar, and penile portions, particularly after surgical repair of the urethra to assess the success of the surgery. The posterior portion of the urethra is visualized better when the procedure is performed with voiding cystourethrography. In women, it may be performed after surgical repair of the urethra to assess the success of the surgery and to assess structural abnormalities in conjunction with an evaluation for voiding dysfunction.

INDICATIONS:

- Aid in the diagnosis of urethral strictures, lacerations, diverticula, and congenital anomalies

RESULT:

Normal findings in:

- Normal size, shape, and course of the membranous, bulbar, and penile portions of the urethra in male patients
- If the prostatic portion can be visualized, it also should appear normal

Abnormal findings in:




- Congenital anomalies, such as urethral valves and perineal hypospadias

- False passages in the urethra
- Prostatic enlargement
- Tumors of the urethra
- Urethral calculi
- Urethral diverticula
- Urethral fistulas
- Urethral strictures and lacerations

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated contrast medium. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status

- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the urethra.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.
- ▶ Obtain a history of the patient's gastrointestinal (GI) and genitourinary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Ensure that this procedure is performed before an upper GI study or barium swallow.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.

- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the procedure. Inform the patient that the procedure is performed in a cystoscopy room by a HCP, with support staff, and takes approximately 30 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Inform the patient that some pressure may be experienced when the catheter is inserted and contrast medium is instilled.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ There are no food or fluid restrictions, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to lie still during the procedure because movement produces unclear images.
- ▶ Obtain and record the patient's baseline vital signs.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Place the patient on the table in a supine position.
- ▶ A single plain film is taken of the bladder and urethra.
- ▶ A catheter is filled with contrast medium to eliminate air pockets and is inserted until the balloon reaches the meatus. Inform the patient that the contrast medium may cause a

temporary flushing of the face, a feeling of warmth, urticaria, headache, vomiting, or nausea.

- ▶ After three-fourths of the contrast medium is injected, another image is taken while the remainder of the contrast medium is injected.
- ▶ The procedure may be done on female patients using a double balloon to occlude the bladder neck from above and below the external meatus.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual activities, as directed by the HCP.
- ▶ Monitor vital and neurological signs every 15 min until they return to preprocedure levels.
- ▶ Monitor fluid intake and urinary output for 24 hr after the procedure. Decreased urine output may indicate impending renal failure.
- ▶ Monitor for signs and symptoms of sepsis, including fever, chills, and severe pain in the kidney area.

▶ Instruct the patient to drink plenty of fluids to prevent stasis and to prevent the buildup of bacteria.

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include CT abdomen, CT pelvis, cystometry, cystoscopy, IVP, MRI abdomen, PSA, renogram, retrograde ureteropyelography, urinalysis, and voiding cystourethrography.
- ▶ Refer to the Genitourinary System table in the back of the book for related tests by body system.

Uric Acid, Blood

SYNONYM/ACRONYM: Urate.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: Spectrophotometry)

Age	Conventional Units	SI Units (Conventional Units × 0.059)
Child less than 12 yr	2.0–5.5 mg/dL	0.12–0.32 mmol/L
Adult younger than 60 yr		
<i>Male</i>	4.4–7.6 mg/dL	0.26–0.45 mmol/L
<i>Female</i>	2.3–6.6 mg/dL	0.14–0.39 mmol/L
Adult older than 60 yr		
<i>Male</i>	4.2–8.0 mg/dL	0.25–0.48 mmol/L
<i>Female</i>	3.5–7.3 mg/dL	0.21–0.43 mmol/L

DESCRIPTION: Uric acid is the end product of purine metabolism. Purines are important constituents of nucleic acids; purine turnover occurs continuously in the body, producing substantial amounts of uric acid even in the absence of purine intake from dietary sources such as organ meats (e.g., liver, thymus gland and/or pancreas [sweetbreads], kidney), legumes, and yeasts. Uric acid is filtered, absorbed, and secreted by the kidneys and is a common constituent of urine. Serum urate levels are affected by the amount of uric acid produced and by the efficiency of renal excretion.

INDICATIONS:

- Assist in the diagnosis of gout when there is a family history (autosomal dominant genetic disorder) or signs and symptoms of gout, indicated by elevated uric acid levels
- Determine the cause of known or suspected renal calculi
- Evaluate the extent of tissue destruction in infection, starvation, excessive exercise, malignancies, chemotherapy, or radiation therapy
- Evaluate possible liver damage in eclampsia, indicated by elevated uric acid levels
- Monitor the effects of drugs known to alter uric acid levels, either as a side effect or as a therapeutic effect

RESULT:

Increased in:

Conditions that result in high cellular turnover release nucleic acids into circulation, which are converted to uric acid by the liver.

- Acute tissue destruction as a result of starvation or excessive exercise (**Related to cellular destruction**)

- Alcoholism
- Chemotherapy and radiation therapy (**Related to high cellular turnover**)
- Chronic lead toxicity (**Cellular destruction related to hemolysis**)
- Congestive heart failure (**Cellular destruction**)
- Diabetes (**Decreased renal excretion results in increased blood levels**)
- Down syndrome
- Eclampsia
- Excessive dietary purines (**Purines are nucleic acid bases converted to uric acid by the liver**)
- Glucose-6-phosphate dehydrogenase deficiency (**Cellular destruction related to hemolysis**)
- Gout (**Usually related to excess dietary intake**)
- Hyperparathyroidism
- Hypertension (**Related to effects on renal excretion**)
- Hypoparathyroidism (**Related to disturbances in calcium and phosphorus homeostasis**)
- Lactic acidosis (**Cellular destruction related to shock**)
- Lead poisoning (**Cellular destruction related to hemolysis**)
- Lesch-Nyhan syndrome (**Disorder of uric acid metabolism**)
- Multiple myeloma (**High cell turnover**)
- Pernicious anemia (**Cellular destruction related to hemolysis**)
- Polycystic kidney disease (**Decreased renal excretion results in increased blood levels**)
- Polycythemia (**Increased cellular destruction**)
- Psoriasis
- Sickle cell anemia (**Cellular destruction related to hemolysis**)
- Type III hyperlipidemia

Decreased in:

- Fanconi's syndrome (**Renal excretion is increased**)
- Low-purine diet (**Insufficient nutrients for liver to synthesize uric acid**)

- Severe liver disease (*Uric acid synthesis occurs in the liver*)
- Wilson's disease (*Affects normal liver function and is related to impaired tubular absorption*)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs and substances that may increase uric acid levels include acetylsalicylic acid (low doses), aldatense, aminothiadiazole, anabolic steroids, antineoplastic agents, ascorbic acid, chlorambucil, chlorthalidone, cisplatin, corn oil, cyclosporine, cyclothiazide, cytarabine, diapamide, diazoxide, diuretics, ergothioneine, ethacrynic acid, ethambutol, ethoxzolamide, etoposide, flumethiazide, hydroflumethiazide, hydroxyurea, ibufenac, ibuprofen, levarterenol, levodopa, mefruside, mercaptopurine, methicillin, methotrexate, methoxyflurane, methyclothiazide, mitomycin, morinamide, polythiazide, prednisone, pyrazinamide, salicylate, spironolactone, theophylline, thiazide diuretics, thioguanine, thiotepa, thiouric acid, triamterene, trichlormethiazide, vincristine, warfarin, and xylitol.
- Drugs that may decrease uric acid levels include acetohexamide, allopurinol, aspirin (high doses), azathioprine, benzbromaron, benziodarone, canola oil, chlorothiazide (given IV), chlorpromazine, chlorprothixene, cinchophen, corticosteroids, corticotropin, clofibrate, coumarin, diatrizoic acid, dicumarol, dipyron, enalapril, fenofibrate, flufenamic acid, guaifenesin, hydralazine, iodipamide, iodopyracet, iopanoic acid, ipodate, lisinopril, mefenamic acid, mersalyl, methotrexate, oxyphenbutazone, phenindione, phenolsulfonphthalein, probenecid, seclazone, sulfipyrazone, and verapamil.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is primarily used to diagnose gout and to evaluate renal function.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex. Especially note pain and edema in joints and great toe (caused by precipitation of sodium urates), headache, fatigue, decreased urinary output, and hypertension.
- ♦ Obtain a history of the patient's genitourinary, hepatobiliary, and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ♦ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ♦ Remove the needle and apply direct pressure with dry gauze to stop

bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Increased uric acid levels may be associated with the formation of kidney stones. Educate the patient, if appropriate, on the importance of drinking a sufficient amount of water when kidney stones are suspected.
- ▶ **Nutritional considerations:** Increased uric acid levels may be associated with gout. Nutritional therapy may be appropriate for some patients identified as having gout. Educate the patient that foods high in oxalic acid include caffeinated beverages, raw blackberries, gooseberries and plums, whole-wheat bread, beets, carrots, beans, rhubarb, spinach, dry cocoa, and Ovaltine. Foods high in purines include organ meats, which should be restricted. In other cases, the requesting HCP may not prescribe a low-purine or purine-restricted diet for treatment of gout because medications can control the condition easily and effectively.

- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include arthroscopy, biopsy bone marrow, calcium, calculus kidney stone panel, cholesterol, collagen cross-linked telopeptide, complete blood count, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology, creatinine, creatinine clearance, gastrin stimulation, G6PD, lactic acid, lead, PTH, parathyroid scan, phosphorus, sickle cell screen, synovial fluid analysis, UA, and urine uric acid.
- ▶ Refer to the Genitourinary, Hepatobiliary, and Musculoskeletal System tables at the back of the book for related tests by body system.

Uric Acid, Urine

SYNONYM/ACRONYM: Urine urate.

SPECIMEN: Urine (5 mL) from a random or timed specimen collected in a clean plastic, unrefrigerated collection container. Sodium hydroxide preservative may be recommended to prevent precipitation of urates.

REFERENCE VALUE: (Method: Spectrophotometry)

Gender	Conventional Units*	SI Units (Conventional Units × 0.0059)
Male	250–800 mg/24 hr	1.48–4.72 mmol/24 hr
Female	250–750 mg/24 hr	1.48–4.43 mmol/24 hr

*Values reflect average purine diet.

DESCRIPTION: Uric acid is the end product of purine metabolism. Purines are important constituents of nucleic acids; purine turnover occurs continuously in the body, producing substantial amounts of uric acid even in the absence of purine intake from dietary sources such as organ meats (e.g., liver, thymus gland and/or pancreas [sweetbreads], kidney), legumes, and yeasts. Uric acid is filtered, absorbed, and secreted by the kidneys and is a common constituent of urine.

- Pernicious anemia (*Related to increased cell turnover*)
- Polycythemia vera (*Related to increased cell turnover*)
- Sickle cell anemia (*Related to increased cell turnover*)

Decreased in:

- Folic acid deficiency
- Lead toxicity
- Severe renal damage (*Possibly resulting from chronic glomerulonephritis, collagen disorders, diabetic glomerulosclerosis, lactic acidosis, ketoacidosis, or alcohol abuse*)

CRITICAL VALUES: N/A

INDICATIONS:

- Compare urine and serum uric acid levels to provide an index of renal function
- Detect enzyme deficiencies and metabolic disturbances that affect the body's production of uric acid
- Monitor the response to therapy with uricosuric drugs
- Monitor urinary effects of disorders that cause hyperuricemia

RESULT:

Increased in:

- Disorders associated with impaired renal tubular absorption, such as Fanconi's syndrome and Wilson's disease
- Disorders of purine metabolism
- Excessive dietary intake of purines
- Gout
- Neoplastic disorders, such as leukemia, lymphosarcoma, and multiple myeloma (*Related to increased cell turnover*)

INTERFERING FACTORS:

- Drugs that may increase urine uric acid levels include acetaminophen, acetohexamide, ampicillin, ascorbic acid, azapropazone, benzbromaron, chlorpromazine, chlorprothixene, corticotropin, coumarin, cytotoxics, diatrizoic acid, dicumarol, ethyl biscoumacetate, glycine, iodipamide, iodopyracet, iopanoic acid, ipodate, levodopa, mannose, merbarone, mercaptopurine, mersalyl, methotrexate, niacinamide, phenindione, phenol-sulfonphthalein, phenylbutazone, phloridzin, probenecid, salicylates (long-term, large doses), seclazone, sulfipyrazone, theophylline, verapamil, and xylitol.
- Drugs that may decrease urine uric acid levels include acetylsalicylic acid (small doses), allopurinol, ascorbic acid, azathioprine, benzbromaron, bumetanide, chlorothiazide, chlorthalidone, citrates, ethacrynic acid, ethambutol, ethoxzolamide, hydrochlorothiazide,

levarterenol, niacin, pyrazinoic acid, and thiazide diuretics.

- All urine voided for the timed collection period must be included in the collection or else falsely decreased values may be obtained. Compare output records with volume collected to verify that all voids were included in the collection.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to identify overexcretors at risk of calculus formation, identify genetic defects, and assist in monitoring therapy for gout.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's genitourinary system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen.

Place a sign in the bathroom to remind the patient to save all urine.

- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ **Sensitivity to social and cultural issues,** as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection containers with the corresponding patient demographics, date, and time of collection.

Random Specimen (collect in early morning):

Clean-catch specimen:

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.
- ▶ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ▶ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ▶ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- ▶ Include on the collection container's label the amount of urine, test start and stop times, and any medications that can affect test results.

General:

- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Increased uric acid levels may be associated with the formation of kidney stones. Educate the patient, if appropriate, on the importance of drinking a

sufficient amount of water when kidney stones are suspected.

- ▶ **Nutritional considerations:** Increased uric acid levels may be associated with gout. Nutritional therapy may be appropriate for some patients identified as having gout. Educate the patient that foods high in oxalic acid include caffeinated beverages, raw blackberries, gooseberries and plums, whole-wheat bread, beets, carrots, beans, rhubarb, spinach, dry cocoa, and Ovaltine. Foods high in purines include organ meats, which should be restricted. In other cases, the requesting HCP may not prescribe a low-purine or purine-restricted diet for treatment of gout because medications can control the condition easily and effectively.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include arthroscopy, biopsy bone marrow, calcium, calculus kidney stone panel, cholesterol, collagen cross-linked telopeptide, complete blood count, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology, creatinine, creatinine clearance, gastrin stimulation, G6PD, lactic acid, lead, oxalate, PTH, parathyroid scan, phosphorus, sickle cell screen, synovial fluid analysis, UA, and blood uric acid.
- ▶ Refer to the Genitourinary System table at the back of the book for related tests by body system.

Urinalysis

SYNONYM/ACRONYM: UA.

SPECIMEN: Urine (15 mL) from an unpreserved, random specimen collected in a clean plastic collection container.

REFERENCE VALUE: (Method: Macroscopic evaluation by dipstick and microscopic examination) Urinalysis comprises a battery of tests including a description of the color and appearance of urine; measurement of specific gravity and pH; and semiquantitative measurement of protein, glucose, ketones, urobilinogen, bilirubin, hemoglobin, nitrites, and leukocyte esterase. Urine sediment may also be examined for the presence of crystals, casts, renal epithelial cells, transitional epithelial cells, squamous epithelial cells, white blood cells (WBCs), red blood cells (RBCs), bacteria, yeast, sperm, and any other substances excreted in the urine that may have clinical significance. Examination of urine sediment is performed microscopically under high power, and results are reported as the number seen per high-power field (hpf). The color of normal urine ranges from light yellow to deep amber. The color depends on the patient's state of hydration (more concentrated samples are darker in color), diet, medication regimen, and exposure to other substances that may contribute to unusual color or odor. The appearance of normal urine is clear. Cloudiness is sometimes attributable to the presence of amorphous phosphates or urates as well as blood, WBCs, fat, or bacteria. Normal specific gravity is 1.001 to 1.029.

Dipstick

pH	5.0–9.0
Protein	Less than 20 mg/dL
Glucose	Negative
Ketones	Negative
Hemoglobin	Negative
Bilirubin	Negative
Urobilinogen	Up to 1 mg/dL
Nitrite	Negative
Leukocyte esterase	Negative
Specific gravity	1.001–1.029

Microscopic Examination

Red blood cells	Less than 5/hpf
White blood cells	Less than 5/hpf
Renal cells	None seen
Transitional cells	None seen
Squamous cells	Rare; usually no clinical significance
Casts	Rare hyaline; otherwise, none seen
Crystals in acid urine	Uric acid, calcium oxalate, amorphous urates
Crystals in alkaline urine	Triple phosphate, calcium phosphate, ammonium biurate, calcium carbonate, amorphous phosphates
Bacteria, yeast, parasites	None seen

DESCRIPTION: Routine urinalysis, one of the most widely ordered laboratory procedures, is used for basic screening purposes. It is a group of tests that evaluate the kidneys' ability to selectively excrete and reabsorb substances while maintaining proper water balance. The results can provide valuable information regarding the overall health of the patient and the patient's response to disease and treatment. The urine dipstick has a number of pads on it to indicate various biochemical markers. Urine pH is an indication of the kidneys' ability to help maintain balanced hydrogen ion concentration in the blood. Specific gravity is a reflection of the concentration ability of the kidneys. Urine protein is the most common indicator of renal disease, although there are conditions that can cause benign proteinuria. Glucose is used as an indicator of diabetes. The presence of ketones indicates impaired carbohydrate metabolism. Hemoglobin indicates the presence of blood, which is associated with renal disease. Bilirubin is used to assist in the detection of

liver disorders. Urobilinogen indicates hepatic or hematopoietic conditions. Nitrites and leukocytes are used to test for bacteriuria and other sources of urinary tract infections (UTIs). Most laboratories have established criteria for the microscopic examination of urine based on patient population (e.g., pediatric, oncology, urology), unusual appearance, and biochemical reactions.

INDICATIONS:

- Determine the presence of a genitourinary infection or abnormality
- Monitor the effects of physical or emotional stress
- Monitor fluid imbalances or treatment for fluid imbalances
- Monitor the response to drug therapy and evaluate undesired reactions to drugs that may impair renal function
- Provide screening as part of a general physical examination, especially on admission to a health care facility or before surgery

RESULT:

Unusual Color

Color	Presence of
Deep yellow	Riboflavin
Orange	Bilirubin, chrysophanic acid, pyridium, santonin
Pink	Beet pigment, hemoglobin, myoglobin, porphyrin, rhubarb
Red	Beet pigment, hemoglobin, myoglobin, porphyrin, uroerythrin
Green	Oxidized bilirubin, Clorets (breathe mint)
Blue	Diagnex, indican, methylene blue
Brown	Bilirubin, hematin, methemoglobin, metronidazole, nitrofurantoin, metabolites of rhubarb, senna
Black	Homogentisic acid, melanin
Smokey	Red blood cells

Test	Increased in	Decreased in
pH	Ingestion of citrus fruits Vegetarian diets Metabolic and respiratory alkalosis	Ingestion of cranberries High-protein diets Metabolic or respiratory acidosis
Protein	Benign proteinuria owing to stress, physical exercise, exposure to cold, or standing Diabetic nephropathy Glomerulonephritis Nephrosis Toxemia of pregnancy	N/A
Glucose	Diabetes	N/A
Ketones	Diabetes Fasting Fever High-protein diets Isopropanol intoxication Postanesthesia period Starvation Vomiting	N/A
Hemoglobin	Diseases of the bladder Exercise (march hemoglobinuria) Glomerulonephritis Hemolytic anemia or other causes of hemolysis (e.g., drugs, parasites, transfusion reaction) Malignancy Menstruation Paroxysmal cold hemoglobinuria Paroxysmal nocturnal hemoglobinuria Pyelonephritis Snake or spider bites Trauma Tuberculosis Urinary tract infections Urolithiasis	N/A
Urobilinogen	Cirrhosis Heart failure Hemolytic anemia Hepatitis Infectious mononucleosis Malaria Pernicious anemia	Antibiotic therapy (suppresses normal intestinal flora) Obstruction of the bile duct
Bilirubin	Cirrhosis Hepatic tumor Hepatitis	N/A

Test	Increased in	Decreased in
Nitrites	Presence of nitrite-forming bacteria (e.g., <i>Citrobacter</i> , <i>Enterobacter</i> , <i>Escherichia coli</i> , <i>Klebsiella</i> , <i>Proteus</i> , <i>Pseudomonas</i> , <i>Salmonella</i> , and some species of <i>Staphylococcus</i>)	N/A
Leukocyte esterase	Bacterial infection Calculus formation Fungal or parasitic infection Glomerulonephritis Interstitial nephritis Tumor	N/A
Specific gravity	Adrenal insufficiency Congestive heart failure Dehydration Diabetes Diarrhea Fever Proteinuria Sweating Vomiting Water restriction X-ray dyes	Diuresis Excess IV fluids Excess hydration Hypothermia Impaired renal concentrating ability

Formed Elements in Urine Sediment

Cellular Elements:

- Clue cells (cell wall of the bacteria causes adhesion to epithelial cells) are present in nonspecific vaginitis caused by *Gardnerella vaginitis*, *Mobiluncus cortisii*, and *Mobiluncus mulieris*.
- RBCs are present in glomerulonephritis, lupus nephritis, focal glomerulonephritis, calculus, malignancy, infection, tuberculosis, infarction, renal vein thrombosis, trauma, hydronephrosis, polycystic kidney, urinary tract disease, prostatitis, pyelonephritis, appendicitis, salpingitis, diverticulitis, gout, scurvy, subacute bacterial endocarditis, infectious mononucleosis, hemoglobinopathies, coagulation disorders, heart failure, and malaria.
- Renal cells that have absorbed cholesterol and triglycerides are also known as *oval fat bodies*.
- Renal cells come from the lining of the collecting ducts, and increased numbers indicate acute tubular damage as seen in acute tubular necrosis, pyelonephritis, malignant nephrosclerosis, acute glomerulonephritis, acute drug or substance (salicylate, lead, or ethylene glycol) intoxication, or chemotherapy, resulting in desquamation, urolithiasis, and kidney transplant rejection.
- Squamous cells line the vagina and distal portion of the urethra. The presence of normal squamous epithelial cells in female urine is generally of no clinical significance. Abnormal cells with enlarged nuclei indicate the need for cytological studies to rule out malignancy.
- Transitional cells line the renal pelvis, ureter, bladder, and proximal portion of the urethra. Increased numbers are seen with infection, trauma, and malignancy.

- WBCs are present in acute UTI, tubulointerstitial nephritis, lupus nephritis, pyelonephritis, kidney transplant rejection, fever, and strenuous exercise.

Casts:

- Granular casts are formed from protein or by the decomposition of cellular elements. They may be seen in renal disease, viral infections, or lead intoxication.
- Large numbers of hyaline casts may be seen in renal diseases, hypertension, congestive heart failure, or nephrotic syndrome, and in more benign conditions such as fever, exposure to cold temperatures, exercise, or diuretic use.
- RBC casts may be found in acute glomerulonephritis, lupus nephritis, and subacute bacterial endocarditis.
- Waxy casts are seen in chronic renal failure or conditions such as kidney transplant rejection, in which there is renal stasis.
- WBC casts may be seen in lupus nephritis, acute glomerulonephritis, interstitial nephritis, and acute pyelonephritis.

Crystals:

- Crystals found in freshly voided urine have more clinical significance than crystals seen in a urine sample that has been standing for more than 2 to 4 hr.
- Calcium oxalate crystals are found in ethylene glycol poisoning, urolithiasis, high dietary intake of oxalates, and Crohn's disease.
- Cystine crystals are seen in patients with cystinosis or cystinuria.
- Leucine or tyrosine crystals may be seen in patients with severe liver disease.
- Large numbers of uric acid crystals are seen in patients with urolithiasis, gout, high dietary intake of foods rich in purines, or who are receiving chemotherapy (see monograph titled "Uric Acid, Urine").

CRITICAL VALUES:

Possible critical values are the presence of uric acid, cystine, leucine, or tyrosine crystals.

The combination of grossly elevated urine glucose and ketones is also considered significant.

Note and immediately report to the health care provider (HCP) any critical values and related symptoms.

INTERFERING FACTORS:

- Certain foods, such as onion, garlic, and asparagus, contain substances that may give urine an unusual odor. An ammonia-like odor may be produced by the presence of bacteria. Urine with a maple syrup–like odor may indicate a congenital metabolic defect (maple syrup urine disease).
- The various biochemical strips are subject to interference that may produce false-positive or false-negative results. Consult the laboratory for specific information regarding limitations of the method in use and a listing of interfering drugs.
- The dipstick method for protein detection is mostly sensitive to the presence of albumin; light-chain or Bence Jones proteins may not be detected by this method. Alkaline pH may produce false-positive protein results.
- Large amounts of ketones or ascorbic acid may produce false-negative or decreased color development on the glucose pad. Contamination of the collection container or specimen with chlorine, sodium hypochlorite, or peroxide may cause false-positive glucose results.
- False-positive ketone results may be produced in the presence of ascorbic acid, levodopa metabolites, valproic acid, phenazopyridine, phenylketones, or phtaleins.

- The hemoglobin pad may detect myoglobin, intact RBCs, and free hemoglobin. Contamination of the collection container or specimen with sodium hypochlorite or iodine may cause false-positive hemoglobin results. Negative or decreased hemoglobin results may occur in the presence of formalin, elevated protein, nitrite, ascorbic acid, or high specific gravity.
- False-negative nitrite results are common. Negative or decreased results may be seen in the presence of ascorbic acid and high specific gravity. Other causes of false-negative values relate to the amount of time the urine was in the bladder before voiding or the presence of pathogenic organisms that do not reduce nitrites to nitrites.
- False-positive leukocyte esterase reactions result from specimens contaminated by vaginal secretions. The presence of high glucose, protein, or ascorbic acid concentrations may cause false-negative results. Specimens with high specific gravity may also produce false-negative results. Patients with neutropenia (e.g., oncology patients) may also have false-negative results because they do not produce enough WBCs to exceed the sensitivity of the biochemical reaction.
- Specimens that cannot be delivered to the laboratory or tested within 1 hr should be refrigerated or should have a preservative added that is recommended by the laboratory. Specimens collected more than 2 hr before submission may be rejected for analysis.
- Because changes in the urine specimen occur over time, prompt and proper specimen processing, storage, and analysis are important to achieve accurate results. Changes that may occur over time include:
 - Production of a stronger odor and an increase in pH (bacteria in the urine break urea down to ammonia)

- A decrease in clarity (as bacterial growth proceeds or precipitates form)
- A decrease in bilirubin and urobilinogen (oxidation to biliverdin and urobilin)
- A decrease in ketones (lost through volatilization)
- Decreased glucose (consumed by bacteria)
- An increase in bacteria (growth over time)
- Disintegration of casts, WBCs, and RBCs
- An increase in nitrite (overgrowth of bacteria)

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis of renal disease, urinary tract infections, and neoplasms of the urinary tract, and as an indication of systemic or inflammatory diseases.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine, genitourinary, immune, hematopoietic, hepatobiliary, and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. If a catheterized specimen is to be collected, explain this procedure to the patient, and obtain a catheterization tray. Address concerns about pain and explain that there should be no discomfort during the procedure. Inform the patient that specimen collection takes approximately 5 to 10 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Random Specimen (collect in early morning):**Clean-catch specimen:**

- ▶ Instruct the male patient to (1) thoroughly wash his hands, (2) cleanse the meatus, (3) void a small amount into the toilet, and (4) void directly into the specimen container.
- ▶ Instruct the female patient to (1) thoroughly wash her hands; (2) cleanse the labia from front to back; (3) while keeping the labia separated, void a small amount into the toilet; and (4) without interrupting the urine stream, void directly into the specimen container.

Pediatric Urine Collector:

- ▶ Put on gloves. Appropriately cleanse the genital area, and allow the area to dry. Remove the covering over the adhesive strips on the collector bag, and apply the bag over the genital area. Diaper the child. When specimen is obtained, place the entire collection bag in a sterile urine container.

Indwelling Catheter:

- ▶ Put on gloves. Empty drainage tube of urine. It may be necessary to clamp off the catheter for 15 to 30 min before specimen collection. Cleanse specimen port with antiseptic swab, and then aspirate 5 mL of urine with a 21- to 25-gauge needle and syringe. Transfer urine to a sterile container.

Urinary Catheterization:

- ▶ Place female patient in lithotomy position or male patient in supine position. Using sterile technique, open the straight urinary catheterization kit and perform urinary catheterization. Place the retained urine in a sterile specimen container.

Suprapubic Aspiration:

- ▶ Place the patient in a supine position. Cleanse the area with antiseptic and drape with sterile drapes. A needle is inserted through the skin into the bladder. A syringe attached to the needle is used to aspirate the urine sample. The needle is then removed and a sterile dressing is applied to the site. Place the sterile sample in a sterile specimen container.
- ▶ Do not collect urine from the pouch from the patient with a urinary diversion (e.g., ileal conduit). Instead, perform catheterization through the stoma.

General:

- ▶ Include on the collection container's label whether the specimen is clean catch or catheter and any medications that may interfere with test results.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to report symptoms such as pain related to tissue inflammation, pain or irritation during void, bladder spasms, or alterations in urinary elimination.
- ▶ Observe for signs of inflammation if the specimen is obtained by suprapubic aspiration.
- ▶ Recognize anxiety related to test results. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Instruct the patient with a UTI, as appropriate, on the proper technique for wiping the perineal area (front to back) after a bowel movement. UTIs are more common in women who use diaphragm/spermicide contraception. These patients can be educated, as appropriate, in the proper insertion and removal of the contraceptive device to avoid recurrent UTIs.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient to begin antibiotic therapy, as prescribed, and instruct the patient in the importance of completing

the entire course of antibiotic therapy even if symptoms are no longer present. Answer any questions or address any concerns voiced by the patient or family.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amino acids, angiography renal, antibodies, anti-glomerular basement membrane,

biopsy bladder, biopsy kidney, bladder cancer marker, BUN, calcium, calculus kidney stone panel, complete blood count, creatinine, culture urine, cystometry, cystoscopy, cystourethrography voiding, cytology urine, electrolytes, glucose, glycated hemoglobin, IFE, IVP, ketones, KUB study, microalbumin, osmolality, oxalate, protein total, phosphorus, renogram, retrograde ureteropyelography, and uric acid (blood and urine).

- ▶ Refer to the Endocrine, Genitourinary, Immune, Hematopoietic, Hepatobiliary, and Reproductive System tables at the back of the book for related tests by body system.

Uterine Fibroid Embolization

SYNONYM/ACRONYM: UFE.

AREA OF APPLICATION: Uterus.

CONTRAST: IV iodine based.

DESCRIPTION: Uterine fibroid embolization (UFE) is a way of treating fibroid tumors of the uterus. Fibroid tumors, also known as myomas, are masses of fibrous and muscle tissue in the uterine wall that are benign, but that may cause heavy menstrual bleeding, pain in the pelvic region, or pressure on the bladder or bowel. Using angiographic methods, a catheter is placed in each of the two uterine arteries, and small particles are injected to block the arterial branches that supply blood to the fibroids. The fibroid tissue dies, the mass shrinks, and the symptoms are relieved. This procedure, which is done under local anesthesia, is less invasive than open surgery done to remove uterine fibroids. Because the effects of uterine fibroid

embolization on fertility are not yet known, the ideal candidate is a premenopausal woman with symptoms from fibroid tumors who no longer wishes to become pregnant. This technique is an alternative for women who do not want to receive blood transfusions or do not wish to receive general anesthesia. This procedure may be used to halt severe bleeding following childbirth or caused by gynecological tumors.




INDICATIONS:

- Treatment for anemia from chronic blood loss
- Treatment of fibroid tumors and tumor vascularity, for both single and multiple tumors
- Treatment of tumors in lieu of surgical resection

RESULT:**Normal findings in:**

- Decrease in uterine bleeding
- Decrease of pelvic pain or fullness

CRITICAL VALUES: N/A**INTERFERING FACTORS:****This procedure is contraindicated for:**

-  Patients with allergies to shellfish or iodinated contrast medium. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.
- Patients with bleeding disorders.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
- Patients in whom cancer is a possibility or who have inflammation or infection in the pelvis.
-  Elderly and other patients who are chronically dehydrated before the procedure, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Complications of the procedure include hemorrhage, infection at

the insertion site, and cardiac arrhythmias.

- The procedure may be terminated if chest pain or severe cardiac arrhythmias occur.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.
- A small percentage of women may pass a small piece of fibroid tissue after the procedure. Women with this problem may require a procedure called a D&C (dilatation and curettage).
- Some women may experience menopause shortly after the procedure.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ◆ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ◆ Inform the patient that the procedure assesses uterine and associated vascular function.
- ◆ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, anesthetics, or contrast medium.

- ▶ Note any recent procedures that can interfere with test results; include examinations utilizing barium- or iodine-based contrast medium.
- ▶ Obtain a history of the patient's reproductive system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain that there may be moments of discomfort and some pain experienced during the test. Explain that a sedative and/or anesthetic may be administered before the procedure to promote relaxation. Inform the patient that the procedure is performed in a radiology or vascular department by a HCP, with support staff, and takes approximately 30 to 120 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives. Usually normal saline is infused.
- ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area

- to be examined prior to the procedure.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Instruct the patient to avoid taking anticoagulant medication or to reduce dosage as ordered prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluids, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Instruct the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs and assess neurological status. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Using a pen, mark the site of the patient's peripheral pulses before angiography; this allows for quicker

and more consistent assessment of the pulses after the procedure.

- ▶ Place the patient in the supine position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ▶ The contrast medium is injected, and a rapid series of images is taken during and after the filling of the vessels to be examined. Delayed images may be taken to examine the vessels after a time and to monitor the venous phase of the procedure.
- ▶ Ask the patient to inhale deeply and hold her breath while the x-ray images are taken, and then to exhale after the images are taken.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure. Monitor and administer an antiemetic agent if ordered. Ready an emesis basin for use.
- ▶ Particles are injected through the catheter to block the blood flow to the fibroids. The particles include polyvinyl alcohol, gelatin sponge (Gelfoam), and microspheres.
- ▶ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, fluids, medications, or activity, as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting,

- ▶ Patients may experience pelvic cramps for several days after the procedure and possible mild nausea and fever.
- ▶ Advise the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Assess extremities for signs of ischemia or absence of distal pulse caused by a catheter-induced thrombus.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema.
- ▶ Recognize anxiety related to test results, and be supportive of impaired activity related to genitourinary system. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage her to review corresponding literature provided by a pharmacist.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count, CT angiography, CT plevis, hysterosalpingography, laparoscopy, MRA, MRI pelvis, PT/INR, and US pelvis.
- ▶ Refer to the Reproductive system table at the back of the book for related tests by body system.

Vanillylmandelic Acid, Urine

SYNONYM/ACRONYM: VMA.

SPECIMEN: Urine (25 mL) from a timed specimen collected in a clean plastic collection container with 6N hydrochloric acid as a preservative.

REFERENCE VALUE: (Method: High-pressure liquid chromatography)

Age	Conventional Units	SI Units (Conventional Units × 5.05)
3–6 yr	1.0–2.6 mg/24 hr	5–13 micromol/24 hr
6–10 yr	2.0–3.2 mg/24 hr	10–16 micromol/24 hr
10–16 yr	2.3–5.2 mg/24 hr	12–26 micromol/24 hr
16–83 yr	1.4–6.5 mg/24 hr	7–33 micromol/24 hr

DESCRIPTION: Vanillylmandelic acid (VMA) is a major metabolite of epinephrine and norepinephrine. It is elevated in conditions that also are marked by overproduction of catecholamines. Creatinine is usually measured simultaneously to ensure adequate collection and to calculate an excretion ratio of metabolite to creatinine.

INDICATIONS:

- Assist in the diagnosis of neuroblastoma, ganglioneuroma, or pheochromocytoma
- Evaluate hypertension of unknown cause

RESULT:

Increased in:

Catecholamine-secreting tumors will cause an increase in VMA.

- Ganglioneuroma
- Hypertension secondary to pheochromocytoma
- Neuroblastoma
- Pheochromocytoma

Decreased in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase VMA levels include ajmaline, chlorpromazine, glucagon, guaifenesin, guanethidine, isoproterenol, methyl dopa, nitroglycerin, oxytetracycline, phenazopyridine, phenolsulfonphthalein, prochlorperazine, rauwolfia, reserpine, sulfobromophthalein, and syrosingopine.
- Drugs that may decrease VMA levels include brofaromine, guanethidine, guanfacine, imipramine, isocarboxazid, methyl dopa, monoamine oxidase inhibitors, morphine, nialamide (in schizophrenics), and reserpine.
- Stress, hypoglycemia, hyperthyroidism, strenuous exercise, smoking, and drugs can produce elevated catecholamines.
- Recent radioactive scans within 1 wk of the test can interfere with test results.
- Failure to collect all urine and store 24-hr specimen properly will result in a falsely low result.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assist in the diagnosis and follow-up treatment of pheochromocytoma, neuroblastoma, and ganglioblastoma. It is also useful in evaluation and follow-up of hypertension.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's endocrine system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Provide a nonmetallic urinal, bedpan, or toilet-mounted collection device. Address concerns about pain and explain that there should be no discomfort during the procedure.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Usually a 24-hr time frame for urine collection is ordered. Inform the patient that all urine must be saved during that 24-hr period. Instruct the patient not to void directly into the laboratory collection container. Instruct the patient to avoid defecating in the collection device and to keep toilet tissue out of the collection device to prevent contamination of the specimen. Place a sign in the bathroom to remind the patient to save all urine.
- ▶ Instruct the patient to void all urine into the collection device and then to pour the urine into the laboratory collection container. Alternatively, the specimen can be left in the collection device for a health care staff member to add to the laboratory collection container.
- ▶ There are no fluid restrictions unless by medical direction.

- ▶ Instruct the patient to abstain from smoking tobacco for 24 hr before testing.
- ▶ Inform the patient of the following dietary, medication, and activity restrictions in preparation for the test:
The patient should not consume foods high in amines for 48 hr before testing (bananas, avocados, beer, aged cheese, chocolate, cocoa, coffee, fava beans, grains, tea, vanilla, walnuts, and red wine).
The patient should not consume foods or fluids high in caffeine for 48 hr before testing (coffee, tea, cocoa, and chocolate).
The patient should not consume any foods or fluids containing vanilla or licorice.
The patient should avoid self-prescribed medications (especially aspirin) and prescribed medications (especially pyridoxine, levodopa, amoxicillin, carbidopa, reserpine, and disulfiram) for 2 wk before testing and as directed.
The patient should avoid excessive exercise and stress during the 24-hr collection of urine. Protocols may vary from facility to facility.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary, medication, and activity restrictions and pretesting preparations prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate collection container with the corresponding patient demographics, date, and time of collection.

Timed Specimen:

- ▶ Obtain a clean 3-L urine specimen container, toilet-mounted collection device, and plastic bag (for transport of the specimen container). The specimen must be refrigerated or kept on ice throughout the entire collection period. If an indwelling urinary catheter is in place, the drainage bag must be kept on ice.

- ◆ Begin the test between 6 and 8 a.m., if possible. Collect first voiding and discard. Record the time the specimen was discarded as the beginning of the timed collection period. The next morning, ask the patient to void at the same time the collection was started and add this last voiding to the container. Urinary output should be recorded throughout the collection time.
- ◆ If an indwelling catheter is in place, replace the tubing and container system at the start of the collection time. Keep the container system on ice during the collection period, or empty the urine into a larger container periodically during the collection period; monitor to ensure continued drainage, and conclude the test the next morning at the same hour the collection was begun.
- ◆ At the conclusion of the test, compare the quantity of urine with the urinary output record for the collection; if the specimen contains less than what was recorded as output, some urine may have been discarded, invalidating the test.
- ◆ Include on the collection container's label the amount of urine, test start and stop times, and ingestion of any foods or medications that can affect test results.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.
- ◆ Instruct the patient to resume usual diet, fluids, medications, and activity, as directed by the HCP.
- ◆ **Nutritional considerations:** Instruct the patient to avoid foods or drinks containing caffeine. Over-the-counter medications should be taken only under the advice of the patient's HCP.
- ◆ Recognize anxiety related to test results, and be supportive of fear of shortened life expectancy. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include angiography adrenal, calcium, catecholamines, CT renal, homovanillic acid, metanephrines, and renin.
- ◆ Refer to the Endocrine System table at the back of the book for related tests by body system.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

Varicella Antibodies

SYNONYM/ACRONYM: Varicella-zoster antibodies, chickenpox, VZ.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: Indirect fluorescent antibody) Negative or less than a fourfold increase in titer.

DESCRIPTION: Varicella-zoster is a double-stranded DNA herpes virus that is responsible for two clinical syndromes, chickenpox and shingles. The incubation period is 2 to 3 wk, and it is highly contagious for about 2 wk beginning 2 days before a rash develops. It is transmitted in respiratory secretions. The primary exposure to the highly contagious virus usually occurs in susceptible school-age children. Adults without prior exposure and who become infected may have severe complications, including pneumonia. Neonatal infection from the mother is possible if exposure occurs during the last 3 wk of gestation. Shingles results when the presumably latent virus is reactivated. The presence of immunoglobulin (Ig) M antibodies indicates acute infection. The presence of IgG antibodies indicates current or past infection. A reactive varicella antibody result indicates immunity but does not protect an individual from shingles. There are also polymerase chain reaction methods that are capable of detecting varicella-zoster DNA in various specimen types.

INDICATIONS:

- Determine susceptibility or immunity to chickenpox

RESULT:

Positive findings in:

- **Varicella infection**

Negative findings in: N/A

CRITICAL VALUES: N/A

INTERFERING FACTORS: N/A

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to confirm diagnosis of varicella infection or immunity.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of exposure to varicella.
- ▶ Obtain a history of the patient's immune and reproductive systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that several tests may be necessary to confirm diagnosis. Any individual positive result should be repeated in 7 to 14 days to monitor a change in titer. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the

patient, and label the appropriate tube with the corresponding patient demographics, date, and time of collection. Perform a venipuncture; collect the specimen in a 5-mL red-top tube.

- ◆ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ◆ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ◆ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ◆ **Vaccination considerations:** Record the date of last menstrual period and determine the possibility of pregnancy prior to administration of varicella vaccine to female varicella-nonimmune patients. Instruct patient not to become pregnant for 1 mo after being vaccinated with the varicella vaccine to protect any fetus from contracting the disease and having serious birth defects. Instruct on birth control methods to prevent pregnancy, if appropriate.
- ◆ Recognize anxiety related to test results, and provide emotional support if results are positive and the patient is pregnant. Inform the patient with shingles about access to pain management. Discuss the implications

of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate. Educate the patient regarding access to counseling services.

- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Instruct the patient in isolation precautions during the time of communicability or contagion. Emphasize the need to return to have a convalescent blood sample taken in 7 to 14 days. Provide information regarding vaccine-preventable diseases where indicated (e.g., encephalitis, hepatitis A and B, human papillomavirus, influenza, measles, mumps, polio, rubella, smallpox, varicella, yellow fever). Answer any questions or address any concerns voiced by the patient or family.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Refer to the Immune and Reproductive System tables at the back of the book for related tests by body system.

Venography, Lower Extremity Studies

SYNONYM/ACRONYM: Phlebography, lower limb venography, venogram.

AREA OF APPLICATION: Veins of the lower extremities.

CONTRAST: IV iodine based.

DESCRIPTION: Venography allows x-ray visualization of the venous vasculature system of the extremities after injection of an iodinated contrast medium. Lower extremity studies identify and locate thrombi within the venous system of the lower limbs. After injection of the contrast medium, x-ray images are taken at timed intervals. Usually both extremities are studied, and the unaffected side is used for comparison with the side suspected of having deep vein thrombosis (DVT) or other venous abnormalities, such as congenital malformations or incompetent valves. Thrombus formation usually occurs in the deep calf veins and at the venous junction and its valves. If DVT is not treated, it can lead to femoral and iliac venous occlusion, or the thrombus can become an embolus, causing a pulmonary embolism. Venography is accurate for thrombi in veins below the knee.

INDICATIONS:

- Assess deep vein valvular competence
- Confirm a diagnosis of DVT
- Determine the cause of extremity swelling or pain
- Determine the source of emboli when pulmonary embolism is suspected or diagnosed
- Distinguish clot formation from venous obstruction
- Evaluate congenital venous malformations
- Locate a vein for arterial bypass graft surgery

RESULT:

Normal findings in:

No obstruction to flow and no filling defects after injection of radiopaque contrast medium; steady opacification of superficial and deep vasculature with no filling defects

Abnormal findings in:

Abnormal results may indicate DVT, deep vein valvular incompetence, or venous obstruction





CRITICAL VALUES:

- DVT

Note and immediately report to the health care provider (HCP) abnormal results and related symptoms.

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the contrast medium may benefit from pre-medication with corticosteroids or the use of nonionic contrast medium.
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother.
-  Elderly and other patients who are chronically dehydrated before the test, because of their risk of contrast-induced renal failure.
-  Patients who are in renal failure.
-  Patients with bleeding disorders.

Factors that may impair clear imaging:

- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images
- Movement of the leg being tested, excessive tourniquet constriction, insufficient injection of contrast medium, and delay between injection and the x-ray
- Severe edema of the legs, making venous access impossible

Other considerations:

- Improper injection of the contrast medium that allows it to seep deep into the muscle tissue.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the venous system of the lower extremities.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, and contrast medium.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Obtain a history of the patient's cardiovascular system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ If contrast medium is scheduled to be used, patients receiving metformin (Glucophage) for non-insulin-dependent (type 2) diabetes should discontinue the drug on the day of the test and continue to withhold it for 48 hr after the test. Failure to do so may result in lactic acidosis.
- ▶ Review the procedure with the patient. Address concerns about pain and explain to the patient that there may be moments of discomfort and some pain experienced during the procedure. Inform the patient that the procedure is usually performed in a radiology or vascular suite by a HCP, with support staff, and takes approximately 30 to 60 min.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives. Usually normal saline is infused.
- ▶ Inform the patient that a burning and flushing sensation may be felt throughout the body during injection of the contrast medium. After injection of the contrast medium, the patient may experience an urge to cough, flushing, nausea, or a salty or metallic taste.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ **Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.**
- ▶ This procedure may be terminated if chest pain, severe cardiac arrhythmias, or signs of a cerebrovascular accident occur.

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ▶ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ▶ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish baseline rhythm; determine if the patient has ventricular arrhythmias.
- ▶ Using a pen, mark the site of the patient's peripheral pulses before venography; this allows for quicker and more consistent assessment of the pulses after the procedure.
- ▶ Place the patient in the supine position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ▶ A local anesthetic is injected at the site, and a small incision is made or a needle inserted.
- ▶ The contrast medium is injected, and a rapid series of images is taken during and after the filling of the vessels to be examined.

- ▶ Instruct the patient to inhale deeply and hold his or her breathe while the x-ray images are taken, and then to exhale.
- ▶ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ▶ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ▶ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.

POST-TEST:

- ▶ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Instruct the patient to resume diet, fluids, and medications, as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ▶ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ▶ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ▶ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ▶ Assess extremities for signs of ischemia or absence of distal pulse caused by a catheter-induced thrombus.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ▶ Instruct the patient to apply cold compresses to the puncture site as needed, to reduce discomfort or edema. Instruct the patient in the care and assessment of the site.

- ▶ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
 - ▶ **Nutritional considerations:** A low-fat, low-cholesterol, and low-sodium diet should be consumed to reduce current disease processes and/or decrease risk of hypertension and coronary artery disease.
 - ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
 - ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include alveolar/arterial gradient, angiography pulmonary, antibodies anticardiolipin, antithrombin III, blood gases, CT angiography, D-dimer, FDP, lactic acid, lung perfusion scan, lung ventilation scan, MRA, MRI abdomen, plethysmography, PT/INR, renogram, US peripheral Doppler, and US venous Doppler extremity studies.
- ▶ Refer to the Cardiovascular System table in the back of the book for related tests by body system.

Vertebroplasty

SYNONYM/ACRONYM: None.

AREA OF APPLICATION: Spine.

CONTRAST: None.

DESCRIPTION: Vertebroplasty is a minimally invasive, nonsurgical therapy used to repair a broken vertebra and to provide relief of pain related to vertebral compression in the spine that has been weakened by osteoporosis or tumoral lesions. Osteoporosis affects over 10 million women in the United States and accounts for over 700,000 vertebral fractures per year. This procedure is usually successful at alleviating the pain caused by a compression fracture less than 6 mo in duration with pain

directly referable to the location of the fracture. Secondary benefits may include vertebra stabilization and reduction of the risk of further compression. This procedure is usually performed on an outpatient basis. The procedure involves injection of orthopedic cement mixture through a needle into a fracture site. Injection is visualized with guidance from radiological imaging. Vertebroplasty may be the preferred procedure when patients are too elderly or frail to tolerate open spinal surgery, or

where bones are too weak for surgical repair. Patients with a malignant tumor may benefit from vertebroplasty. Other possible applications include younger patients whose osteoporosis is caused by long-term steroid use or a metabolic disorder. This procedure is recommended after basic treatments such as bed rest and orthopedic braces have failed, or when pain medication has been ineffective or caused the patient medical problems, including stomach ulcers.

INDICATIONS:

- Assist in the detection of nonmalignant tumors before surgical resection.
- Repair of compression spinal fractures of varying ages. Fractures older than 6 mo will respond but at a slower rate. Fractures less than 4 wk old should be given a chance to heal without intervention unless they are associated with disabling pain or hospitalization.
- Repair of spinal problems due to tumors.

RESULT:

Normal findings in:

- Improvement in the ability to ambulate without pain
- Relief of back pain


Abnormal findings in:

- Failure to reduce the patient's pain
- Failure to improve the patient's mobility

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

-  Patients with allergies to shellfish or iodinated dye. The contrast medium used may

cause a life-threatening allergic reaction. Patients with a known hypersensitivity to the contrast medium may benefit from premedication with corticosteroids or the use of nonionic contrast medium.

- Pain that is primarily radicular in nature
- Patients with bleeding disorders
- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother
- Pain that is improving or that has been present and unchanged for years
- Imaging procedures that suggest no fracture is present or that the fracture is remote from the patient's pain

Factors that may impair clear imaging:

- Gas or feces in the gastrointestinal tract resulting from inadequate cleansing or failure to restrict food intake before the study
- Retained barium from a previous radiological procedure
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

Other considerations:

- Complications of the procedure include hemorrhage, infection at the insertion site, and cardiac arrhythmias.
- The procedure may be terminated if chest pain, or severe cardiac arrhythmias occur.
- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status, may interfere with the test results.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.
- Consultation with a health care provider (HCP) should occur before

the procedure for radiation safety concerns regarding younger patients or patients who are lactating.

- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should wear a protective lead apron or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure improves the spinal column function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, anesthetics, or contrast medium.
- ▶ Note any recent procedures that can interfere with test results, including examinations using barium- or iodine-based contrast medium.
- ▶ Obtain a history of the patient's musculoskeletal system, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the patient's current medications, including anticoagulants, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals, especially those known to affect coagulation (see Appendix F). Such products should be discontinued by medical direction for the appropriate number of days prior to a surgical procedure. Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain and

explain that there may be moments of discomfort and some pain experienced during the test. Inform the patient that the procedure is usually performed in the radiology department by a HCP, with support staff, and takes approximately 30 to 90 min.

- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Explain that an IV line may be inserted to allow infusion of IV fluids, contrast medium, or sedatives. Usually normal saline is infused.
- ▶ Instruct the patient to remove jewelry and other metallic objects from the area to be examined prior to the procedure.
- ▶ Instruct the patient to fast and restrict fluids for 8 hr prior to the procedure. Protocols may vary from facility to facility.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*
- ▶ This procedure may be terminated if chest pain or severe cardiac arrhythmias occur.

INTRATEST:

- ▶ Ensure the patient has complied with dietary, fluid, and medication restrictions for 8 hr prior to the procedure.
- ▶ Ensure the patient has removed all external metallic objects from the area to be examined.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure. Use nonionic contrast medium for the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still throughout the procedure because movement produces unreliable results.
- ▶ Record baseline vital signs, and continue to monitor throughout the procedure. Protocols may vary from facility to facility.

- ◆ Observe standard precautions, and follow the general guidelines in Appendix A.
- ◆ Establish an IV fluid line for the injection of emergency drugs and of sedatives.
- ◆ Administer an antianxiety agent, as ordered, if the patient has claustrophobia. Administer a sedative to a child or to an uncooperative adult, as ordered.
- ◆ Place electrocardiographic electrodes on the patient for cardiac monitoring. Establish baseline rhythm; determine if the patient has ventricular arrhythmias.
- ◆ Place the patient in the prone position on an exam table. Cleanse the selected area, and cover with a sterile drape.
- ◆ A local anesthetic is injected at the site, and a small incision is made or a needle inserted under fluoroscopy.
- ◆ Orthopedic cement is injected through the needle into the fracture.
- ◆ Ask the patient to inhale deeply and hold his or her breath while the images are taken, and then to exhale.
- ◆ Instruct the patient to take slow, deep breaths if nausea occurs during the procedure.
- ◆ Monitor the patient for complications related to the procedure (e.g., allergic reaction, anaphylaxis, bronchospasm).
- ◆ The needle or catheter is removed, and a pressure dressing is applied over the puncture site.
- ◆ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ◆ Observe for delayed allergic reactions, such as rash, urticaria, tachycardia, hyperpnea, hypertension, palpitations, nausea, or vomiting.
- ◆ Instruct the patient to immediately report symptoms such as fast heart rate, difficulty breathing, skin rash, itching, or decreased urinary output.
- ◆ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation. Any pleuritic pain, persistent right shoulder pain, or abdominal pain should be reported to the appropriate HCP.
- ◆ Instruct the patient's caregiver to apply cold compresses to the puncture site as needed, to reduce discomfort or edema. Instruct the patient and caregiver in the care and assessment of the site.
- ◆ Instruct the patient to maintain bed rest for 4 to 6 hr after the procedure or as ordered.
- ◆ Recognize anxiety related to test results, and be supportive of impaired activity related to physical activity. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ◆ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

POST-TEST:

- ◆ A report of the examination will be sent to the requesting HCP, who will discuss the results with the patient.
- ◆ Instruct the patient to resume usual diet, fluids, medications, or activity, as directed by the HCP. Renal function should be assessed before metformin is resumed.
- ◆ Monitor vital signs and neurological status every 15 min for 1 hr, then every 2 hr for 4 hr, and then as ordered by the HCP. Take temperature every 4 hr for 24 hr. Compare with baseline values. Notify the HCP if temperature is elevated. Protocols may vary from facility to facility.
- ◆ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ◆ Related tests include bone mineral densitometry, bone scan, CT spine, EMG, and MRI musculoskeletal.
- ◆ Refer to the Musculoskeletal System table in the back of the book for related tests by body system.

Visual Fields Test

SYNONYM/ACRONYM: Perimetry, VF.

AREA OF APPLICATION: Eyes.

CONTRAST: N/A.

DESCRIPTION: The visual field (VF) is the area within which objects can be seen by the eye as it fixes on a central point. The central field is an area extending 25° surrounding the fixation point. The peripheral field is the remainder of the area within which objects can be viewed. This test evaluates the central VF, except within the physiological blind spot, through systematic movement of the test object across a tangent screen. It tests the function of the retina, optic nerve, and optic pathways. VF testing may be performed manually by the examiner (confrontation VF exam) or by using partially or fully automated equipment (tangent screen, Goldman, Humphrey VF exam). In the manual VF test the patient is asked to cover one eye and fix his or her gaze on the examiner. The examiner moves his or her hand out of the patient's VF and then gradually brings it back into the patient's VF. The patient signals the examiner when the hand comes back into view. The test is repeated on the other eye. The manual test is frequently used for screening because it is quick and simple. Tangent screen or Goldman testing is an automated method commonly used to create a map of the patient's VF and is described in greater detail in this monograph.

INDICATIONS:

- Detect field vision loss and evaluate its progression or regression

RESULT:

Normal findings in:

- Normal central vision field will form a circle extending 25° superiorly, nasally, inferiorly, and temporally; 12° to 15° temporal to the central fixation point is a physiological blind spot, approximately 1.5° below the horizontal meridian. It is approximately 7.5° high and 5.5° wide. The patient should be able to see the test object throughout the entire central vision field except within the physiological blind spot.

Abnormal findings in:

- Amblyopia
- Blepharochalasis
- Blurred vision
- Brain tumors
- Cerebrovascular accidents
- Choroidal nevus
- Diabetes with ophthalmic manifestations
- Glaucoma
- Headache
- Macular degeneration
- Macular drusen
- Nystagmus
- Optic neuritis or neuropathy
- Ptosis of eyelid
- Retinal detachment, hole, or tear
- Retinal exudates or hemorrhage
- Retinal occlusion of the artery or vein
- Retinitis pigmentosa

- Subjective visual disturbance
- Use of high-risk medications
- VF defect
- Vitreous traction syndrome

CRITICAL VALUES: N/A

INTERFERING FACTORS:

Factors that may impair the results of the examination:

- An uncooperative patient or a patient with severe vision loss who has difficulty seeing even a large vision screen may have test results that are invalid.
- Assess and make note of the patient's cooperation and reliability as good, fair, or poor, because it is difficult to evaluate factors such as general health, fatigue, or reaction time that affect test performance.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure detects visual field function.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens.
- ▶ Obtain a history of the patient's known or suspected vision loss, changes in visual acuity, including type and cause; use of glasses or contact lenses; eye conditions with treatment regimens; eye surgery; and other tests and procedures to assess and diagnose visual deficit.
- ▶ Obtain a history of symptoms and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Measurement of visual acuity with and without corrective lenses prior to testing is highly recommended. Instruct the patient to wear corrective lenses, if appropriate and if worn to correct for

distance vision. Instruct the patient regarding the importance of keeping the eyes open for the test.

- ▶ Review the procedure with the patient. Address concerns about pain and explain that no discomfort will be experienced during the test. Inform the patient that a health care provider (HCP) performs the test, in a quiet, darkened room, and that to evaluate both eyes, the test can take up 30 min.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Instruct the patient to cooperate fully and to follow directions. Ask the patient to remain still during the procedure because movement produces unreliable results.
- ▶ Seat the patient 3 ft away from the tangent screen with the eye being tested directly in line with the central fixation tangent, usually a white disk, on the screen. Cover the eye that is not being tested. Ask the patient to place the chin in the chin rest and gently press the forehead against the support bar. Reposition the patient as appropriate to ensure the eye(s) to be tested are properly aligned in front of the VF testing equipment. While the patient stares at the disk on the screen the examiner will move an object toward the patient's visual field. The patient signals the examiner when the object enters their visual field. The patient's responses are recorded and a map of the patient's VF, including areas of visual defect, can be drawn on paper manually or by a computer.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Recognize anxiety related to test results, and encourage the patient to recognize and be supportive of impaired activity related to vision loss, perceived loss of driving privileges, or the possibility of requiring corrective lenses (self-image). Discuss the implications of the test results on the

patient's lifestyle. Provide contact information, if desired, for a general patient education Web site on the topic of eye care (e.g., www.allaboutvision.com). Provide contact information regarding vision aids, if desired, for ABLEDATA (sponsored by the National Institute on Disability and Rehabilitation Research [NIDRR], available at www.abledata.com). Information can also be obtained from the American Macular Degeneration Foundation (www.macular.org), the Glaucoma Research Foundation (www.glaucoma.org), and the American Diabetes Association (www.diabetes.org).

- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Instruct the patient in the use of any ordered medications. Explain the importance of adhering to the therapy regimen. As appropriate, instruct the

patient in significant side effects and systemic reactions associated with the prescribed medication. Encourage him or her to review corresponding literature provided by a pharmacist.

- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include fluorescein angiography, fructosamine, fundus photography, glucagon, glucose, glycated hemoglobin, gonioscopy, insulin, intraocular pressure, microalbumin, plethysmography, and slit-lamp biomicroscopy.
- ▶ Refer to the Ocular System table at the back of the book for related tests by body system.

Vitamin B₁₂

SYNONYM/ACRONYM: Cyanocobalamin.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: Immunochemiluminescent assay)

Age	Conventional Units	SI Units (Conventional Units × 0.738)
Newborn–11 mo	160–1300 pg/mL	118–959 pmol/L
Adult	200–900 pg/mL	148–664 pmol/L

DESCRIPTION: Vitamin B₁₂ has a ringed crystalline structure that surrounds an atom of cobalt. It is essential in DNA synthesis, hematopoiesis, and central nervous system (CNS) integrity. It is

derived solely from dietary intake. Animal products are the richest source of vitamin B₁₂. Its absorption depends on the presence of intrinsic factor. Circumstances that may result in

a deficiency of this vitamin include the presence of stomach or intestinal disease as well as insufficient dietary intake of foods containing vitamin B₁₂. A significant increase in red blood cell (RBC) mean corpuscular volume may be an important indicator of vitamin B₁₂ deficiency.

INDICATIONS:

- Assist in the diagnosis of CNS disorders
- Assist in the diagnosis of megaloblastic anemia
- Evaluate alcoholism
- Evaluate malabsorption syndromes

RESULT:

Increased in:

Increases are noted in a number of conditions; pathophysiology is not clear.

- Chronic granulocytic leukemia
- Chronic obstructive pulmonary disease
- Chronic renal failure
- Diabetes
- Leukocytosis
- Liver cell damage (hepatitis, cirrhosis) (**Stores in damaged hepatocytes will be released into circulation; synthesis of transport proteins is diminished by liver damage**)
- Obesity
- Polycythemia vera (**Pathophysiology is not well understood**)
- Protein malnutrition (**Lack of transport proteins will increase circulating levels**)
- Severe congestive heart failure
- Some carcinomas

Decreased in:

- Abnormalities of cobalamin transport or metabolism
- Bacterial overgrowth (**Vitamin will be consumed and utilized by the bacteria**)

- Crohn's disease (**Related to poor absorption**)
- Dietary deficiency (e.g., in vegetarians)
- *Diphyllobothrium* (fish tapeworm) infestation (**Vitamin will be consumed and utilized by the parasite**)
- Gastric or small intestine surgery (**Related to dietary deficiency or poor absorption**)
- Hypochlorhydria (**Ineffective digestion resulting in poor absorption**)
- Inflammatory bowel disease (**Related to dietary deficiency or poor absorption**)
- Intestinal malabsorption
- Intrinsic factor deficiency (**Required for proper vitamin B₁₂ absorption**)
- Late pregnancy (**Related to dietary deficiency or poor absorption**)
- Pernicious anemia (**Related to dietary deficiency or poor absorption**)

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase vitamin B₁₂ levels include chloral hydrate.
- Drugs that may decrease vitamin B₁₂ levels include alcohol, aminosalicylic acid, anti-convulsants, ascorbic acid, cholestyramine, cimetidine, colchicine, metformin, neomycin, oral contraceptives, ranitidine, and triamterene.
- Hemolysis or exposure of the specimen to light invalidates results.
- Specimen collection soon after blood transfusion can falsely increase vitamin B₁₂ levels.
- Failure to follow dietary restrictions before the procedure may cause the procedure to be canceled or repeated.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to diagnose and monitor vitamin B₁₂ deficiency.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal and hematopoietic systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to fast for at least 12 hr before specimen collection. Protocols may vary from facility to facility.
- ▶ There are no fluid or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 12 hr prior to the procedure.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the

patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture. Protect the specimen from light.

- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ Instruct the patient to resume usual diet, as directed by the HCP.
- ▶ *Nutritional considerations:* Instruct the patient with a deficiency of vitamin B₁₂, as appropriate, in the use of vitamin supplements. Inform the patient, as appropriate, that the best dietary sources of vitamin B₁₂ are meats, fish, poultry, eggs, and milk.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include complete blood count, complete blood count, RBC count, complete blood count, RBC indices, complete blood count, RBC morphology, complete blood count, WBC count and differential, folate, gastric acid stimulation, gastrin stimulation, homocysteine, and intrinsic factor antibodies.
- ▶ Refer to the Gastrointestinal and Hematopoietic System tables at the back of the book for related tests by body system.

Vitamin D

SYNONYM/ACRONYM: Cholecalciferol, vitamin D 1,25-dihydroxy.

SPECIMEN: Serum (1 mL) collected in a red-top tube. Plasma (1 mL) collected in green-top (heparin) tube is also acceptable.

REFERENCE VALUE: (Method: High-performance liquid chromatography)

Form	Conventional Units	SI Units (Conventional Units × 2.496)
Vitamin D 25-dihydroxy	9–52 ng/mL	22.5–129.8 nmol/L
Vitamin D 1,25-dihydroxy	15–60 pg/mL	37.4–149.8 pmol/L

DESCRIPTION: There are two metabolically active forms of vitamin D. Ergocalciferol (vitamin D₂) is formed when ergosterol in plants is exposed to sunlight. Ergocalciferol is absorbed by the stomach and intestine when orally ingested. Cholecalciferol (vitamin D₃) is formed when the skin is exposed to sunlight or ultraviolet light. Vitamins D₂ and D₃ enter the bloodstream after absorption. Vitamin D₃ is converted to vitamin D 25-dihydroxy by the liver and is the major circulating form of the vitamin. Vitamin D₂ is converted to vitamin D 1,25-dihydroxy by the kidneys and is the more biologically active form. Vitamin D acts with parathyroid hormone and calcitonin to regulate calcium metabolism and osteoblast function.

INDICATIONS:

- Differential diagnosis of disorders of calcium and phosphorus metabolism
- Evaluate deficiency or suspected toxicity
- Investigate bone diseases
- Investigate malabsorption

RESULT:

Increased in:

- Endogenous Vitamin D intoxication (*In conditions such as sarcoidosis, cat scratch disease, and some lymphomas, extrarenal conversion of 25-dihydroxy to 1,25-dihydroxy vitamin D occurs with a corresponding abnormal elevation of calcium.*)
- Exogenous Vitamin D intoxication

Decreased in:

- Bowel resection (*Related to lack of absorption*)
- Celiac disease (*Related to lack of absorption*)
- Inflammatory bowel disease (*Related to lack of absorption*)
- Malabsorption (*Related to lack of absorption*)
- Osteomalacia (*Related to dietary insufficiency*)
- Pancreatic insufficiency (*Lack of digestive enzymes to metabolize fat-soluble Vitamin D; malabsorption*)
- Rickets (*Related to dietary insufficiency*)
- Thyrotoxicosis (*Possibly related to increased calcium loss through sweat, urine, or feces*)

with corresponding decrease in Vitamin D levels)

CRITICAL VALUES: 

Vitamin toxicity can be as significant as problems brought about by vitamin deficiencies. The potential for toxicity is especially important to consider with respect to fat-soluble vitamins, which are not eliminated from the body as quickly as water-soluble vitamins and can accumulate in the body. Most cases of toxicity are brought about by oversupplementing and can be avoided by consulting a qualified nutritionist for recommended daily dietary and supplemental allowances. Signs and symptoms of vitamin D toxicity include nausea, loss of appetite, vomiting, polyuria, muscle weakness, and constipation.

INTERFERING FACTORS:

- Drugs that may increase vitamin D levels include etidronate disodium and pravastatin.
- Drugs and substances that may decrease vitamin D levels include aluminum hydroxide, anticonvulsants, cholestyramine, colestipol, glucocorticoids, isoniazid, mineral oil, and rifampin.
- Recent radioactive scans or radiation within 1 wk before the test can interfere with test results when radioimmunoassay is the test method.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate vitamin D toxicity or deficiency.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's gastrointestinal and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ *Nutritional considerations:* Educate the patient with vitamin D deficiency, as appropriate, that the main dietary sources of vitamin D are fortified dairy foods and cod liver oil. Explain to the patient that vitamin D is also synthesized by the body, in the skin, and is activated by sunlight.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include amylase, ANCA, biopsy intestinal, calcium, capsule endoscopy, colonoscopy, fecal analysis, fecal fat, antibodies gliadin antibodies, kidney stone panel, laparoscopy abdominal, lipase, osteocalcin, oxalate, phosphorus, and proctosigmoidoscopy.
- Refer to the Gastrointestinal and Musculoskeletal System tables at the back of the book for related tests by body system.

Vitamin E

SYNONYM/ACRONYM: Tocopherol.

SPECIMEN: Serum (1 mL) collected in a red- or tiger-top tube.

REFERENCE VALUE: (Method: High-performance liquid chromatography)

Age	Conventional Units	SI Units (Conventional Units × 23.22)
1–12 yr	0.3–0.9 mg/dL	7–21 micromol/L
13–19 yr	0.6–1.0 mg/dL	14–23 micromol/L
Adult	0.5–1.8 mg/dL	12–42 micromol/L

DESCRIPTION: Vitamin E is a powerful fat-soluble antioxidant that prevents the oxidation of unsaturated fatty acids, which can combine with polysaccharides to form deposits in tissue. For this reason, vitamin E is believed to reduce the risk of coronary artery disease. Vitamin E reserves in lung tissue provide a barrier against air pollution and protect red blood cell (RBC) membrane integrity from oxidation. Oxidation of fatty acids in RBC membranes can result in irreversible membrane damage and hemolysis. Studies are in progress to confirm the suspicion that oxidation also

contributes to the formation of cataracts and macular degeneration of the retina. Because vitamin E is found in a wide variety of foods, a deficiency secondary to inadequate dietary intake is rare.

INDICATIONS:

- Evaluate neuromuscular disorders in premature infants and adults
- Evaluate patients with malabsorption disorders
- Evaluate suspected hemolytic anemia in premature infants and adults
- Monitor patients on long-term parenteral nutrition

RESULT:**Increased in:**

- Obstructive liver disease
- Vitamin E intoxication

Decreased in:

- Abetalipoproteinemia (**Rare inherited disorder of fat metabolism resulting in poor absorption of fat and fat-soluble vitamin E**)
- Hemolytic anemia (**Vitamin E is an important antioxidant that protects RBC cell membranes from weakening; deficiencies can result in hemolysis**)
- Malabsorption disorders, such as biliary atresia, cirrhosis, cystic fibrosis, chronic pancreatitis, pancreatic carcinoma, and chronic cholestasis

CRITICAL VALUES: 

Vitamin toxicity can be as significant as problems brought about by vitamin deficiencies. The potential for toxicity is especially important to consider with respect to fat-soluble vitamins, which are not eliminated from the body as quickly as water-soluble vitamins and can accumulate in the body. Most cases of toxicity are brought about by oversupplementing and can be avoided by consulting a qualified nutritionist for recommended daily dietary and supplemental allowances. *Note:* Excessive supplementation of vitamin E (greater than 60 times the Recommended Dietary Allowance over a period of 1 yr or longer) can result in excessive bleeding, delayed healing of wounds, and depression.

INTERFERING FACTORS:

- Drugs that may increase vitamin E levels include anticonvulsants (in women).
- Drugs that may decrease vitamin E levels include anticonvulsants (in men).
- Exposure of the specimen to light decreases vitamin E levels, resulting in a falsely low result.

NURSING IMPLICATIONS AND PROCEDURE**PRETEST:**

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to evaluate vitamin E toxicity or deficiency.
- ♦ Obtain a history of the patient's complaints, including a list of known allergies, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's cardiovascular, gastrointestinal, hematopoietic, and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ♦ Observe standard precautions, and follow the general guidelines in Appendix A.
- ♦ Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ♦ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ♦ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- ▶ **Nutritional considerations:** Educate the patient with a vitamin E deficiency, if appropriate, that the main dietary sources of vitamin E are vegetable oils, whole grains, wheat germ, milk, eggs, meats, fish, and green leafy vegetables. Vitamin E is fairly stable at most cooking temperatures (except frying) and when exposed to acidic foods.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need

for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include amylase, antibodies gliadin, biopsy bone marrow, biopsy intestinal, capsule endoscopy, colonoscopy, complement, complete blood count, complete blood count, hematocrit, complete blood count, hemoglobin, complete blood count, RBC count, complete blood count, RBC indices, and complete blood count, RBC morphology, Coomb's antiglobulin direct and indirect, fecal analysis, fecal fat, Ham's test, Hgb electrophoresis, laparoscopy abdominal, lipase, osmotic fragility, and proctosigmoidoscopy.
- ▶ Refer to the Cardiovascular, Gastrointestinal, Hematopoietic, and Hepatobiliary System tables at the back of the book for related tests by body system.

Vitamin K

SYNONYM/ACRONYM: Phylloquinone, phytonadione.

SPECIMEN: Serum (1 mL) collected in a red-top tube.

REFERENCE VALUE: (Method: High-performance liquid chromatography)

Conventional Units	SI Units (Conventional Units × 2.22)
0.13–1.19 ng/mL	0.29–2.64 nmol/L

DESCRIPTION: Vitamin K is one of the fat-soluble vitamins. It is essential for the formation of prothrombin; factors VII, IX, and X; and proteins C and S. Vitamin K also works with vitamin D in synthesizing bone protein, and regulating calcium levels (see monograph titled "Vitamin D.") Vitamin K levels are not often requested, but vitamin K is often prescribed as a medication. Approximately one-half of the body's vitamin K is produced by

intestinal bacteria; the other half is obtained from dietary sources. There are three forms of vitamin K: vitamin K₁, or phylloquinone, which is found in foods; vitamin K₂, or menaquinone, which is synthesized by intestinal bacteria; and vitamin K₃, or menadione, which is the synthetic, water-soluble, pharmaceutical form of the vitamin. Vitamin K₃ is two to three times more potent than the naturally occurring forms.

INDICATIONS:

Evaluation of bleeding of unknown cause (e.g., frequent nosebleeds, bruising).

RESULT:**Increased in:**

- Excessive administration of vitamin K

Decreased in:

- Antibiotic therapy (**By decreasing intestinal flora**)
- Chronic fat malabsorption (**Due to lack of digestive enzymes and poor absorption**)
- Cystic fibrosis (**Due to lack of digestive enzymes and poor absorption**)
- Diarrhea (in infants) (**Increased loss in feces**)
- Gastrointestinal disease (**Related to malabsorption**)
- Hemorrhagic disease of the newborn (**Newborns normally have low levels of vitamin K. Neonates at risk are those who are not given a prophylactic vitamin K shot at birth or those receiving nutrition strictly from breast milk, which has less vitamin K than cow's milk**)
- Hypoprothrombinemia (**Prothrombin is a vitamin K-dependent protein**)
- Liver disease (**Interferes with storage of vitamin K**)
- Obstructive jaundice (**Damages hepatocytes and interferes with storage of vitamin K**)
- Pancreatic disease (**Insufficient enzymes to metabolize vitamin K**)

CRITICAL VALUES: 

Vitamin toxicity can be as significant as problems brought about by vitamin deficiencies. The potential for toxicity is especially important to consider with respect to fat-soluble vitamins, which are not eliminated from the body as quickly as water-soluble vitamins and can accumulate in the body. The naturally occurring

forms, vitamin K₁ and K₂, do not cause toxicity. Signs and symptoms of vitamin K₃ toxicity include bleeding and jaundice. Possible interventions include withholding the source.

INTERFERING FACTORS:

Drugs and substances that may decrease vitamin K levels include antibiotics, cholestyramine, coumarin, mineral oil, and warfarin.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ♦ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ♦ Inform the patient that the test is used to assist in the evaluation of symptoms relating to chronic antibiotic therapy and investigation of bleeding of unknown etiology.
- ♦ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ♦ Obtain a history of the patient's hematopoietic and hepatobiliary systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ♦ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ♦ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ♦ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ♦ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ♦ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ♦ Instruct the patient to cooperate fully and to follow directions. Direct the

patient to breathe normally and to avoid unnecessary movement.

- Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.
- Nutritional considerations:** Inform the patient with a vitamin K deficiency, as appropriate, that the main dietary sources of vitamin K are cabbage, cauliflower, spinach and other green leafy vegetables, pork, liver, soybeans, and vegetable oils.
- Instruct the patient to report bleeding from any areas of the skin or mucous membranes.

- Inform the patient of the importance of taking precautions against bleeding or bruising, including the use of a soft bristle toothbrush, use of an electric razor, avoidance of constipation, avoidance of aspirin products, and avoidance of intramuscular injections.

- Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- Related tests include ALT, antithrombin III, AST, bilirubin, chloride sweat, complete blood count, fecal analysis, fecal fat, GGT, and PT/INR.
- Refer to the Hematopoietic and Hepatobiliary System tables at the back of the book for related tests by body system.

Vitamins A, B₁, B₆, and C

SYNONYM/ACRONYM: Vitamin A: retinol, carotene; vitamin B₁: thiamine; vitamin B₆: niacin, pyroxidine, P-5'-P, pyridoxyl-5-phosphate; vitamin C: ascorbic acid.

SPECIMEN: Serum (1 mL) collected in a red-top tube each for vitamins A and C; plasma (1 mL) collected in a lavender-top (EDTA) tube each for vitamins B₁ and B₆.

REFERENCE VALUE: (Method: High-performance liquid chromatography)

Vitamin	Age	Conventional Units	SI Units
Vitamin A	1–6 yr	20–43 mcg/dL	(Conventional Units × 0.0349) 0.70–1.50 micromol/L
	7–12 yr	26–49 mcg/dL	0.91–1.71 micromol/L
	13–19 yr	26–72 mcg/dL	0.91–2.51 micromol/L
	Adult	30–120 mcg/dL	1.05–4.19 micromol/L
Vitamin B ₁		0.21–0.43 mcg/dL	(Conventional Units × 29.6) 6.2–12.8 micromol/L
Vitamin B ₆		5–30 ng/mL	(Conversion Factor × 4.046) 20–121 nmol/L
Vitamin C		0.6–1.9 mg/dL	(Conventional Units × 56.78) 34.1–107.9 micromol/L

DESCRIPTION: Vitamin assays are used in the measurement of nutritional status. Low levels indicate inadequate oral intake, poor nutritional status, or malabsorption problems. High levels indicate excessive intake, vitamin intoxication, or absorption problems. Vitamin A is a fat-soluble nutrient that promotes normal vision and prevents night blindness; contributes to growth of bone, teeth, and soft tissues; supports thyroxine formation; maintains epithelial cell membranes, skin, and mucous membranes; and acts as an anti-infection agent. Vitamins B₁, B₆, and C are water soluble. Vitamin B₁ acts as an enzyme and plays an important role in the Krebs cycle. Vitamin B₆ is important in heme synthesis and functions as a coenzyme in amino acid metabolism and glycogenolysis. It includes pyridoxine, pyridoxal, and pyridoxamine. Vitamin C promotes collagen synthesis, maintains capillary strength, facilitates release of iron from ferritin to form hemoglobin, and functions in the stress response.

INDICATIONS:

Vitamin A:

- Assist in the diagnosis of night blindness
- Evaluate skin disorders
- Investigate suspected vitamin A deficiency

Vitamin B₁:

- Investigate suspected beriberi
- Monitor the effects of chronic alcoholism

Vitamin B₆:

- Investigate suspected malabsorption or malnutrition
- Investigate suspected vitamin B₆ deficiency

Vitamin C:

- Investigate suspected metabolic or malabsorptive disorders
- Investigate suspected scurvy

RESULT:

Increased in:

- Vitamin A:
Chronic kidney disease
Idiopathic hypercalcemia in infants
Vitamin A toxicity

Decreased in:

- Vitamin A:
Abetalipoproteinemia (*Related to poor absorption*)

- Carcinoid syndrome (*Related to poor absorption*)
- Chronic infections (*Deficiency in vitamin A decreases ability to fight infection*)
- Cystic fibrosis (*Related to poor absorption*)
- Disseminated tuberculosis (*Related to poor absorption*)
- Hypothyroidism (*Condition decreases ability of beta carotene to convert to vitamin A*)
- Infantile blindness (*Related to dietary deficiency*)
- Liver, gastrointestinal (GI), or pancreatic disease (*Related to malabsorption or poor absorption*)
- Night blindness (*Related to chronic dietary deficiency or lack of absorption*)
- Protein malnutrition (*Related to dietary deficiency*)
- Sterility and teratogenesis (*Related to dietary deficiency*)
- Zinc deficiency (*Zinc is required for generation of vitamin A transport proteins*)

- Vitamin B₁:

- Alcoholism (*Related to dietary deficiency*)
- Carcinoid syndrome (*Related to dietary deficiency or lack of absorption*)
- Hartnup disease (*Related to dietary deficiency*)
- Pellagra (*Related to dietary deficiency*)

- Vitamin B₆: (*This vitamin is involved in many essential functions like nucleic acid synthesis, enzyme activation, antibody production, electrolyte balance, and RBC formation. Deficiencies result in a variety of conditions.*)

- Alcoholism (*Related to dietary deficiency*)
- Asthma
- Carpal tunnel syndrome
- Gestational diabetes
- Lactation (*Related to dietary deficiency and/or increased demand*)
- Malabsorption
- Malnutrition

- Neonatal seizures
- Normal pregnancies (*Related to dietary deficiency and/or increased demand*)
- Occupational exposure to hydrazine compounds (*Enzymatic pathways are altered by hydralazines in a manner that increases excretion of vitamin B₆*)
- Pellagra (*Related to dietary deficiency*)
- Pre-eclamptic edema
- Renal dialysis
- Uremia

- Vitamin C:

- Alcoholism (*Related to dietary deficiency*)
- Anemia (*Related to dietary deficiency*)
- Cancer (*Related to dietary deficiency or lack of absorption*)
- Hemodialysis (*Vitamin C is lost during the treatment*)
- Hyperthyroidism (*Related to dietary deficiency and/or increased demand*)
- Malabsorption
- Pregnancy (*Related to dietary deficiency and/or increased demand*)
- Rheumatoid disease
- Scurvy (*Related to dietary deficiency or lack of absorption*)

CRITICAL VALUES:

Vitamin toxicity can be as significant as problems brought about by vitamin deficiencies. The potential for toxicity is especially important to consider with respect to fat-soluble vitamins (A, D, E, and K), which are not eliminated from the body as quickly as water-soluble vitamins and can accumulate in the body. Most cases of toxicity are brought about by oversupplementing and can be avoided by consulting a qualified nutritionist for recommended daily dietary and supplemental allowances. Signs and symptoms of vitamin A toxicity may include headache, blurred vision, bone pain, joint pain, dry skin, and loss of appetite.

INTERFERING FACTORS:

- Drugs and substances that may increase vitamin A levels include

alcohol (moderate intake), oral contraceptives, and probucol.

- Drugs and substances that may decrease vitamin A levels include alcohol (chronic intake, alcoholism), allopurinol, cholestyramine, colestipol, mineral oil, and neomycin.
- Drugs that may decrease vitamin B₁ levels include glibenclamide, isoniazid, and valproic acid.
- Drugs that may decrease vitamin B₆ levels include amiodarone, anticonvulsants, cycloserine, disulfiram, ethanol, hydralazine, isoniazid, levodopa, oral contraceptives, penicillamine, pyrazinoic acid, and theophylline.
- Drugs and substances that may decrease vitamin C levels include acetylsalicylic acid, aminopyrine, barbiturates, estrogens, heavy metals, oral contraceptives, nitrosamines, and paraldehyde.
- Chronic tobacco smoking decreases vitamin C levels.
- Various diseases may affect vitamin levels (see Results section).
- Diets high in freshwater fish and tea, which are thiamine antagonists, may cause decreased vitamin B₁ levels.
- Long-term hyperalimentation may result in decreased vitamin levels.
- Exposure of the specimen to light decreases vitamin levels, resulting in a falsely low results.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to assess hypervitaminosis or deficiency.
- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

- ▶ Obtain a history of the patient's GI, genitourinary, hepatobiliary, immune, and musculoskeletal systems, symptoms, and results of previously performed laboratory tests and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ **Sensitivity to social and cultural issues**, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to fast for at least 12 hr before specimen collection for vitamin A.
- ▶ There are no fluid or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ Ensure that the patient has complied with dietary restrictions; assure that food has been restricted for at least 12 hr prior to the vitamin A test.
- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tubes with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

♦ **Nutritional considerations:** Educate the patient with a specific vitamin deficiency, as appropriate, regarding dietary sources of these vitamins. Advise the patient to ask a nutritionist to develop a diet plan recommended for his or her specific needs.

Vitamin A:

♦ The main source of vitamin A comes from carotene, a yellow pigment noticeable in most fruits and vegetables, especially carrots, sweet potatoes, squash, apricots, and cantaloupe. It is also present in spinach, collards, broccoli, and cabbage. This vitamin is fairly stable at most cooking temperatures, but it is destroyed easily by light and oxidation.

Vitamin B₁:

♦ Vitamin B₁ is the most stable with respect to the effects of environmental factors. It is found in meats, coffee, peanuts, and legumes. The body is also capable of making some vitamin B₁ by converting the amino acid tryptophan to niacin.

Vitamin B₆:

♦ Good sources of vitamin B₆ include meats (especially beef and pork), whole grains, wheat germ, legumes (beans, peas, lentils), potatoes, oatmeal, and bananas. As with other water-soluble vitamins, it is best preserved by rapid cooking, although it is relatively stable at most cooking temperatures (except frying) and when exposed to acidic foods. This vitamin is destroyed rapidly by light and alkalis.

Vitamin C:

♦ Citrus fruits are excellent dietary sources of vitamin C. Other good sources are green and red peppers, tomatoes, white potatoes, cabbage, broccoli, chard, kale, turnip greens, asparagus, berries, melons, pineapple, and guava. Vitamin C is destroyed by exposure to air, light, heat, or alkalis. Boiling water before cooking eliminates dissolved oxygen that destroys vitamin C in the process of boiling. Vegetables should be crisp and cooked as quickly as possible.

General:

♦ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.

♦ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

♦ Related tests include amylase, BUN, chloride sweat, complete blood count, creatinine, lipase, prealbumin, TSH, FT₄, and zinc.

♦ Refer to the Gastrointestinal, Genitourinary, Hepatobiliary, Immune, and Musculoskeletal System tables at the back of the book for related tests by body system.

White Blood Cell Scan

SYNONYM/ACRONYM: WBC imaging, inflammatory scan, labeled leukocyte scan, infection scintigraphy, labeled autologous leukocytes.

AREA OF APPLICATION: Whole body.

CONTRAST: IV radionuclide combined with white blood cells.

W

DESCRIPTION: Because white blood cells (WBCs) naturally accumulate in areas of inflammation, the WBC scan uses radiolabeled WBCs to help determine the site of an acute infection or confirm the presence or absence of infection or inflammation at a suspected site. A gamma camera detects the radiation emitted from the injected radionuclide, and a representative image of the radionuclide distribution is obtained and recorded or stored electronically. Because of its better image resolution and greater specificity for acute infections, the WBC scan has replaced scanning with gallium-67 citrate (Ga-67). Some chronic infections associated with pulmonary disease, however, may be better imaged with Ga-67. The WBC scan is especially helpful in detecting postoperative infection sites and in documenting lack of residual infection after a course of therapy.

INDICATIONS:

- Aid in the diagnosis of infectious or inflammatory diseases
- Differentiate infectious from noninfectious process
- Evaluate the effects of treatment
- Evaluate inflammatory bowel disease (IBD)
- Evaluate patients with fever of unknown origin
- Evaluate postsurgical sites and wound infections
- Evaluate suspected infection of an orthopedic prosthesis
- Evaluate suspected osteomyelitis

RESULT:

Normal findings in:

- No focal localization of the radionuclide, along with some slight localization of the radionuclide within the reticuloendothelial system (liver, spleen, and bone marrow)

Abnormal findings in:

- Abscess
- Arthritis
- Infection
- Inflammation
- IBD
- Osteomyelitis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

This procedure is contraindicated for:

- Patients who are pregnant or suspected of being pregnant, unless the potential benefits of the procedure far outweigh the risks to the fetus and mother

Factors that may impair clear imaging:

- Inability of the patient to cooperate or remain still during the procedure because of age, significant pain, or mental status
- Retained barium from a previous radiological procedure, which may inhibit visualization of an abdominal lesion
- Metallic objects (e.g., jewelry, body rings) within the examination field, which may inhibit organ visualization and cause unclear images

- Other nuclear scans done within 48 hr and Ga-67 scans within 4 wk before the procedure
- Lesions smaller than 1 to 2 cm, which may not be detectable
- A distended bladder, which may obscure pelvic detail

Other considerations:

- Improper injection of the radionuclide that allows the tracer to seep deep into the muscle tissue produces erroneous hot spots.
- Patients with a low WBC count may need donor WBCs to complete the radionuclide labeling process; otherwise, Ga-67 scanning should be performed instead.
- False-negative images may be a result of hemodialysis, hyperglycemia, hyperalimentation, steroid therapy, and antibiotic therapy.
- The presence of multiple myeloma or thyroid cancer can result in a false-negative scan for bone abnormalities.
- Consultation with a health care provider (HCP) should occur before the procedure for radiation safety concerns regarding younger patients or patients who are lactating.
- Risks associated with radiation overexposure can result from frequent x-ray procedures. Personnel in the room with the patient should stand behind a shield or leave the area while the examination is being done. Personnel working in the examination area should wear badges to record their level of radiation exposure.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the procedure assesses the presence of inflammation or infection.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex, iodine, seafood, contrast medium, or anesthetics.
- ▶ Obtain a history of the patient's immune system, symptoms, and results of previously performed laboratory tests, diagnostic and surgical procedures.
- ▶ Note any recent procedures that can interfere with test results, including barium examinations.
- ▶ Record the date of the last menstrual period and determine the possibility of pregnancy in perimenopausal women.
- ▶ Obtain a list of the medications the patient is taking, including anticoagulant therapy, aspirin and other salicylates, herbs, nutritional supplements, and nutraceuticals (see Appendix F). Note the last time and dose of medication taken.
- ▶ Review the procedure with the patient. Address concerns about pain related to the procedure and explain to the patient that some pain may be experienced during the test, and there may be moments of discomfort. Reassure the patient that the radionuclide poses no radioactive hazard and rarely produces side effects. Inform the patient that the procedure is performed in a nuclear medicine department by a HCP and usually takes approximately 1 to 6 hr, and that delayed images are needed 24 hr later. The patient may leave the department and return later to undergo delayed imaging.
- ▶ *Sensitivity to social and cultural issues*, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ Instruct the patient to remove jewelry and other metallic objects in the area to be examined.
- ▶ There are no dietary or medication restrictions prior to the procedure, unless by medical direction.
- ▶ *Make sure a written and informed consent has been signed prior to the procedure and before administering any medications.*

INTRATEST:

- ▶ Ensure the patient has removed all external metallic objects prior to the procedure.
- ▶ If the patient has a history of allergic reactions to any substance or drug, administer ordered prophylactic steroids or antihistamines before the procedure.
- ▶ Have emergency equipment readily available.
- ▶ Instruct the patient to void prior to the procedure and to change into the gown, robe, and foot coverings provided.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A.
- ▶ Administer sedative to a child or to an uncooperative adult, as ordered.
- ▶ On the day of the test, draw a 50- to 80-mL sample of blood for separating the WBCs from the blood and an in vitro process of labeling with radionuclide.
- ▶ IV radionuclide-labeled autologous WBCs are administered.
- ▶ Images are recorded 1 to 6 hr post injection depending on the radionuclide used. Delayed images may be required at 24 hr after the injection.
- ▶ If abdominal abscess or infection is suspected, laxatives or enemas may be ordered before delayed imaging.

POST-TEST:

- ▶ A report of the results will be sent to the requesting HCP, who will discuss the results with the patient.
- ▶ Unless contraindicated, advise patient to drink increased amounts of fluids for 24 to 48 hr to eliminate the radionuclide from the body. Inform the patient that radionuclide is eliminated from the body within 6 to 24 hr.
- ▶ No other radionuclide tests should be scheduled for 24 to 48 hr after this procedure.
- ▶ Observe the needle/catheter insertion site for bleeding, inflammation, or hematoma formation.
- ▶ Instruct the patient in the care and assessment of the injection site. Observe for bleeding, hematoma formation, and inflammation.

- ▶ If a woman who is breastfeeding must have a nuclear scan, she should not breastfeed the infant until the radionuclide has been eliminated. This could take as long as 3 days. She should be instructed to express the milk and discard it during the 3-day period to prevent cessation of milk production.
- ▶ Instruct the patient to immediately flush the toilet, and to meticulously wash hands with soap and water after each voiding for 24 hr after the procedure.
- ▶ Instruct all caregivers to wear gloves when discarding urine for 24 hr after the procedure. Wash gloved hands with soap and water before removing gloves. Then wash hands after the gloves are removed.
- ▶ Recognize anxiety related to test results, and be supportive of perceived loss of independent function. Discuss the implications of abnormal test results on the patient's lifestyle. Provide teaching and information regarding the clinical implications of the test results, as appropriate.
- ▶ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP. Answer any questions or address any concerns voiced by the patient or family.
- ▶ Depending on the results of this procedure, additional testing may be needed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ▶ Related tests include angiography pulmonary, bone scan, colonoscopy, complete blood count, complete blood count, WBC count and differential, CT abdomen, CT pelvis, CT spine, culture (blood, skin, wound), ESR, fecal analysis, gallium scan, GI blood loss scan, KUB, MRI musculoskeletal, MRI pelvis, MRI spine, proctosigmoidoscopy, radiography bone, and US abdomen, US pelvis and vitamin D.
- ▶ Refer to the Immune System table in the back of the book for related tests by body system.

Zinc

SYNONYM/ACRONYM: Zn.

SPECIMEN: Serum (1 mL) collected in a trace element–free, royal blue–top tube.

REFERENCE VALUE: (Method: Atomic absorption spectrophotometry)

Z

Age	Conventional Units	SI Units (Conventional Units × 0.153)
Newborn–6 mo	26–141 mcg/dL	4.0–21.6 micromol/L
6–11 mo	29–131 mcg/dL	4.5–20.1 micromol/L
1–4 yr	31–115 mcg/dL	4.8–17.6 micromol/L
4–5 yr	48–119 mcg/dL	7.4–18.2 micromol/L
6–9 yr	48–129 mcg/dL	7.3–19.7 micromol/L
10–13 yr	25–148 mcg/dL	3.9–22.7 micromol/L
14–17 yr	46–130 mcg/dL	7.1–19.9 micromol/L
Adult	70–120 mcg/dL	10.7–18.4 micromol/L

DESCRIPTION: Zinc is found in all body tissues, but the highest concentrations are found in the eye, bone, and male reproductive organs. Zinc is involved in RNA and DNA synthesis and is essential in the process of tissue repair. It is also required for the formation of collagen and the production of active vitamin A (for the visual pigment rhodopsin). Zinc also functions as a chelating agent to protect the body from lead and cadmium poisoning. Zinc is absorbed from the small intestine. Its absorption and excretion seem to be through the same sites as those for iron and copper. The body does not store zinc as it does copper and iron. Untreated zinc deficiency in infants may result in a condition called acrodermatitis enteropathica. Symptoms include growth retardation, diarrhea, impaired wound healing, and frequent infections. Adolescents and adults with zinc deficiency exhibit similar adverse effects on growth, sexual development, and immune function, as well

as altered taste and smell, emotional instability, impaired adaptation to darkness, impaired night vision, tremors, and a bullous, pustular rash over the extremities.

INDICATIONS:

- Assist in confirming acrodermatitis enteropathica
- Evaluate nutritional deficiency
- Evaluate possible toxicity
- Monitor replacement therapy in individuals with identified deficiencies
- Monitor therapy of individuals with Wilson's disease

RESULT:

Increased in:

Zinc is contained in and secreted by numerous types of cells in the body. Damaged cells release zinc into circulation and increase blood levels.

- Anemia
- Arteriosclerosis
- Coronary heart disease
- Primary osteosarcoma of the bone

Decreased in:

This trace metal is an essential component of enzymes that participate in protein and carbohydrate metabolism. It is involved in DNA replication, insulin storage, carbon dioxide gas exchange, cellular immunity and healing, promotion of body growth, and sexual maturity. Deficiencies result in a variety of conditions.

- Acrodermatitis enteropathica
(Congenital abnormality that affects zinc uptake and results in zinc deficiency)
- AIDS
- Acute infections
- Acute stress
- Burns
- Cirrhosis
- Conditions that decrease albumin
- Diabetes
- Long-term total parenteral nutrition
- Malabsorption
- Myocardial infarction
- Nephrotic syndrome
- Nutritional deficiency
- Pregnancy
- Pulmonary tuberculosis

CRITICAL VALUES: N/A

INTERFERING FACTORS:

- Drugs that may increase zinc levels include auranofin, chlorthalidone, corticotropin, oral contraceptives, and penicillamine.
- Drugs that may decrease zinc levels include anticonvulsants, cisplatin, citrates, corticosteroids, estrogens, interferon, and oral contraceptives.

NURSING IMPLICATIONS AND PROCEDURE

PRETEST:

- ▶ Positively identify the patient using at least two unique identifiers before providing care, treatment, or services.
- ▶ Inform the patient that the test is used to evaluate disorders associated with

abnormal zinc levels and monitor response to therapy.

- ▶ Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.
- ▶ Obtain a history of the patient's gastrointestinal, hepatobiliary, immune, and musculoskeletal systems, symptoms, and results of previously performed laboratory tests, and diagnostic and surgical procedures.
- ▶ Obtain a list of the patient's current medications, including herbs, nutritional supplements, and nutraceuticals.
- ▶ Review the procedure with the patient. Inform the patient that specimen collection takes approximately 5 to 10 min. Address concerns about pain and explain that there may be some discomfort during the venipuncture.
- ▶ ***Sensitivity to social and cultural issues***, as well as concern for modesty, is important in providing psychological support before, during, and after the procedure.
- ▶ There are no food, fluid, or medication restrictions, unless by medical direction.

INTRATEST:

- ▶ If the patient has a history of allergic reaction to latex, avoid the use of equipment containing latex.
- ▶ Instruct the patient to cooperate fully and to follow directions. Direct the patient to breathe normally and to avoid unnecessary movement.
- ▶ Observe standard precautions, and follow the general guidelines in Appendix A. Positively identify the patient, and label the appropriate tube with the corresponding patient demographics, date, and time of collection. Perform a venipuncture.
- ▶ Remove the needle and apply direct pressure with dry gauze to stop bleeding. Observe venipuncture site for bleeding or hematoma formation and secure gauze with adhesive bandage.
- ▶ Promptly transport the specimen to the laboratory for processing and analysis.

POST-TEST:

- ▶ A report of the results will be sent to the requesting health care provider (HCP), who will discuss the results with the patient.

- ♦ **Nutritional considerations:** Topical or oral supplementation may be ordered for patients with zinc deficiency. Dietary sources high in zinc include shellfish, red meat, wheat germ, and processed foods such as canned pork and beans and canned chili. Patients should be informed that diets high in phytates from whole grains, coffee, cocoa, or tea bind zinc and prevent it from being absorbed. Decreases in zinc also can be induced by increased intake of iron, copper, or manganese. Vitamin and mineral supplements with a greater than 3:1 iron/zinc ratio inhibit zinc absorption.
- ♦ Reinforce information given by the patient's HCP regarding further testing, treatment, or referral to another HCP.

- Answer any questions or address any concerns voiced by the patient or family.
- ♦ Depending on the results of this procedure, additional testing may be performed to evaluate or monitor progression of the disease process and determine the need for a change in therapy. Evaluate test results in relation to the patient's symptoms and other tests performed.

RELATED MONOGRAPHS:

- ♦ Related tests include albumin, complete blood count, complete blood count, WBC and differential, copper, iron, and vitamin A.
- ♦ Refer to the Gastrointestinal, Immune, Hepatobiliary, and Musculoskeletal System tables at the back of the book for related tests by body system.

System Tables

Auditory System

Laboratory Tests Associated with the Auditory System

Antibiotic Drugs—Aminoglycosides: Amikacin, Gentamicin, Tobramycin; Tricyclic Glycopeptide: Vancomycin, 92–96
Culture, Bacterial, Anal/Genital, Ear, Eye, Skin, and Wound, 492–497
Zinc, 1234–1236

Diagnostic Tests Associated with the Auditory System

Audiometry hearing loss, 153–156	Otoscopy, 905–907
Computed Tomography, Brain, 416–420	Spondee speech reception threshold, 1071–1073
Evoked Brain Potentials, 590–594	Tuning fork tests, 1122–1125
Magnetic Resonance Imaging, Brain, 836–839	

SYS

Cardiovascular System

Laboratory Tests Associated with the Cardiovascular System

Anion gap, 83–86	Complete Blood Count, Hemoglobin, 372–378
Apolipoprotein A and B, 140–143	Homocysteine and methylmalonic acid, 709–711
Aspartate aminotransferase, 149–152	International Normalized Ratio (INR), 1007–1011
Atrial natriuretic factor, 152–153	Lactate dehydrogenase and isoenzymes, 775
Blood gases, 221–222	Lactic acid, 776–779
B-type natriuretic peptide, 254–255	Lidocaine, 86–92
Calcium, blood, 259–263	Lipoprotein electrophoresis, 799–800
Calcium, ionized, 264–267	Magnesium, blood, 822–824
Chloride, 306–310	Myoglobin, 764–765
Cholesterol, HDL and LDL, 325–329	Pericardial fluid analysis, 931–934
Cholesterol, total, 329–333	Potassium, blood, 227–232
C-reactive protein, 470–472	Procainamide, 86–92
Creatine kinase and isoenzymes, 472–475	Prothrombin time and INR, 1007–1011
D-Dimer, 539–541	Quinidine, 86–92
Digoxin, 86–92	Triglycerides, 1108–1111
Disopyramide, 86–92	Troponins I and T, 1116–1118
Erythrocyte Sedimentation Rate, 577–580	Vitamin E, 1222–1224
Fibrin degradation products, 617–619	
Flecainide, 86–92	
Complete Blood Count, Hematocrit, 365–372	

Diagnostic Tests Associated with the Cardiovascular System

Angiography, carotid, 66–69	Myocardial infarct scan, 885–888
Angiography, coronary, 70–73	Myocardial perfusion heart scan, 888–893
Antibodies, antistreptolysin O, 110–111	Plethysmography, 950–954
Blood pool imaging, 237–241	Positron emission tomography, fluorodeoxyglucose, 598–601
Chest x-ray, 301–303	Positron emission tomography, heart, 966–970
Computed tomography, angiography, 408–412	Ultrasound, arterial Doppler, carotid, 1126–1128
Echocardiography, 551–554	Ultrasound, arterial Doppler, lower and upper extremity studies, 1128–1131
Echocardiography, transesophageal, 554–557	Ultrasound, venous Doppler, extremity studies, 1168–1170
Electrocardiogram, 557–561	Venography, lower extremity studies, 1207–1211
Exercise stress test, 594–597	
Holter monitoring, 707–709	
Magnetic resonance angiography, 829–831	
Magnetic resonance imaging, chest, 843–846	

Endocrine System**Laboratory Tests Associated with the Endocrine System**

Adrenocorticotrophic hormone (and challenge tests), 7–12	Gastrin and gastrin stimulation test, 645–647
Albumin, 15–18	Glucagon, 654–657
Aldosterone, 19–22	Glucose (random, 2-hour postprandial), 657
Amylase, 51–53	Glucose tolerance tests, 665–669, 1109–1111
Angiotensin-converting enzyme, 82–83	Glycated hemoglobin, 672–674
Anion gap, 83–86	Growth hormone, stimulation and suppression tests, 682–684
Antibodies, antithyroglobulin and antithyroid peroxidase, 112–113	Homovanillic acid, 712–714
Antidiuretic hormone, 128–130	Human chorionic gonadotropin, 714–717
Biopsy, thyroid, 215–217	5-Hydroxyindoleacetic acid, 724–726
Calcitonin, 256–259	Insulin and insulin response to glucose, 744–747
Calcium, ionized, 264–267	Insulin antibodies, 748–749
Calcium, urine, 267–271	Ketones, blood and urine, 769–770
Catecholamines, Blood and Urine, 286–290	Lactic acid, 776–779
Chloride, blood, 306–310	Luteinizing hormone, 813–816
Chloride, sweat, 311–314	Magnesium, blood, 822–824
Cortisol and challenge tests, 463	Magnesium, urine, 825–828
C-peptide, 467–469	Metanephrines, 871
Dehydroepiandrosterone sulfate, 541–543	Metyrapone stimulation, 464–467
Dexamethasone suppression test, 464–467	Microalbumin, 876–879
Estradiol, 589–590	Osmolality, blood and urine, 899–902
Follicle-stimulating hormone, 628–631	
Fructosamine, 631–633	

Laboratory Tests Associated with the Endocrine System

Parathyroid hormone: intact, C-terminal, and N-terminal, 919–922	Thyroglobulin, 1087–1088
Phosphorus, blood, 939–942	Thyroid-binding inhibitory immunoglobulin, 1089
Phosphorus, urine, 942–945	Thyroid-stimulating hormone, 1093–1095
Potassium, blood, 974–978	Thyroid-stimulating immunoglobulins, 1096–1097
Potassium, urine, 978–982	Thyroxine-binding globulin, 1097–1099
Prealbumin, 982–984	Thyroxine, free, 1099–1101
Progesterone, 988–990	Thyroxine, total, 1101–1104
Prolactin, 990–993	Triiodothyronine, free, 1112–1113
Renin, 1035–1039	Triiodothyronine, total, 1114–1116
Sodium, blood, 1064–1067	Vanillylmandelic acid, 1203–1205
Sodium, urine, 1068–1071	
Testosterone, total, 1084–1086	

SYS

Diagnostic Tests Associated with the Endocrine System

Adrenal gland scan, 4–7	Magnetic resonance imaging, pituitary, 858–861
Angiography, adrenal, 62–65	Parathyroid scan, 923–925
Computed tomography, pancreas, 429–433	Radioactive iodine uptake, 1021–1023
Computed tomography, pituitary, 437–441	Thyroid scan, 1089–1092
Magnetic resonance imaging, pancreas, 851–854	Ultrasound, pancreas, 1152–1154
	Ultrasound, thyroid and parathyroid, 1166–1168

Gastrointestinal System**Laboratory Tests Associated with the Gastrointestinal System**

Albumin and albumin/globulin ratio, 15–18	D-Xylose tolerance test, 547–550
Ammonia, 43–45	Fecal analysis, 602–604
Amylase, 51–53	Fecal fat, 605–608
Anion gap, 83–86	Folate, 626–628
Antibodies, antineutrophilic cytoplasmic, 102–104	Fructosamine, 631–633
Antibodies, gliadin (immunoglobulin G and immunoglobulin A), 115–117	Gastric acid stimulation test, 639–642
Biopsy, intestinal, 188–190	Gastrin and gastrin stimulation test, 645–647
Calcium, blood, 259–263	Gram stain, 677–679
Carcinoembryonic antigen, 282–285	<i>Helicobacter pylori</i> antibody, 687–688
Chloride, blood, 306–310	Complete Blood Count, Hematocrit, 365–372
Cholesterol, total, 329–333	Complete Blood Count, Hemoglobin, 372–378
Complete blood count, 360–367	5-Hydroxyindoleacetic acid, 724–726
Culture, bacterial, stool, 506–509	Immunoglobulins A, D, G, and M, 735–738
Culture, viral, 517–519	

(table continues on page 1240)

Laboratory Tests Associated with the Gastrointestinal System

Intrinsic factor antibodies, 759–760	Complete Blood Count, RBC count, 383–388
Lactose tolerance test, 779–781	Complete Blood Count, Red blood cell indices, 388–391
Lipase, 797–799	Triglycerides, 1108–1111
Magnesium, blood, 822–824	Vitamin A, 1226–1230
Magnesium, urine, 825–828	Vitamin B ₁ , 1226–1230
Ova and parasites, stool, 603–604	Vitamin B ₆ , 1226–1230
Oxalate, 910–912	Vitamin B ₁₂ , 1217–1219
Peritoneal fluid analysis, 935–938	Vitamin C, 1226–1230
Phosphorus, blood, 935–942	Vitamin D, 1226–1230
Potassium, blood, 974–978	Vitamin E, 1222–1224
Potassium, urine, 978–982	Zinc, 1234–1236
Prealbumin, 982–984	
Protein, blood, total and fractions, 995–998	

Diagnostic Tests Associated with the Gastrointestinal System

Barium enema, 157–159	Gastrointestinal blood loss scan, 651–654
Barium swallow, 160–162	Hepatobiliary scan, 701–704
Capsule endoscopy, 273–276	Kidney, ureter, and bladder study, 770–772
Cholangiography, percutaneous transhepatic, 314–318	Laparoscopy, 782–785
Cholangiography, postoperative, 318–321	Liver scan, 800–803
Cholangiopancreatography, endoscopic retrograde, 321–324	Magnetic resonance imaging, abdomen, 832–835
Colonoscopy, 346–350	Magnetic resonance imaging, pancreas, 851–854
Computed tomography, abdomen, 403–407	Proctosigmoidoscopy, 985–988
Computed tomography, pancreas, 429–433	Ultrasound, liver and biliary system, 1147–1149
Esophageal manometry, 582–585	Ultrasound, pancreas, 1152–1154
Esophagogastroduodenoscopy, 586–589	Upper gastrointestinal and small bowel series, 1171–1174
Gastric emptying scan, 642–645	Urea Breath Test, 1175–1177
Gastroesophageal reflux scan, 648–650	

Genitourinary System**Laboratory Tests Associated with the Genitourinary System**

Acetaminophen, 54–57	Antibodies, antineutrophilic cytoplasmic, 102–104
Acid phosphatase, prostatic, 3–4	Antibodies, anti-glomerular basement membrane, 99–100
Albumin and albumin/globulin ratio, 15–18	Antidiuretic hormone, 128–130
Aldosterone, 19–22	Biopsy, bladder, 166–169
Amikacin, 92–96	Biopsy, kidney, 191–194
Ammonia, 43–45	Biopsy, prostate, 208–211
Anion gap, 83–86	

Laboratory Tests Associated with the Genitourinary System

Bladder cancer markers, urine, 218–219	Methotrexate, 739–742
Calcitonin and calcitonin stimulation tests, 256–259	Microalbumin, 876–879
Calcium, blood, 259–263	β_2 -Microglobulin, 878–883
Calcium, ionized, 264–267	Osmolality, blood and urine, 899–902
Calcium, urine, 267–271	Oxalate, urine, 910–912
Calculus, kidney stone panel, 271–272	Phosphorus, blood, 939–942
Carbon dioxide, 276–279	Phosphorus, urine, 942–945
Chloride, blood, 306–310	Potassium, blood, 974–978
Creatinine, blood, 476–479	Potassium, urine, 978–982
Creatinine, urine, and creatinine clearance, urine, 480–484	Prostate-specific antigen, 993–995
Culture, bacterial, urine, 511–514	Protein, urine, total quantitative and fractions, 995–998
Culture, viral, 517–519	Renin, 1035–1039
Cyclosporine, 739–742, 825–828	Salicylate, 54–57
Cytology, urine, 534–536	Sodium, blood, 1064–1067
Erythropoietin, 580–582	Sodium, urine, 1068–1071
Gentamicin, 92–96	Tobramycin, 92–96
Gram stain, 677–679	Urea nitrogen, blood, 1177–1180
Lithium, 131–134	Urea nitrogen, urine, 1180–1182
Magnesium, blood, 822–824	Uric acid, blood, 1185–1188
Magnesium, urine, 825–828	Uric acid, urine, 1188–1191
	Urinalysis, 1192–1199
	Vancomycin, 92–96

Diagnostic Tests Associated with the Genitourinary System

Amino Acid, blood, 35–38	Kidney, ureter, and bladder study, 770–772
Amino Acid, urine, 39–41	Complete Blood Count, RBC count, 383–388
Angiography, renal, 78–82	Renogram, 1156, 1039–1042
Antibodies, antistreptolysin O, 110–111	Ultrasound, bladder, 1139–1141
Computed tomography, pelvis, 433–437	Ultrasound, kidney, 1144–1147
Computed tomography, renal, 441–445	Ultrasound, pelvis, 1155–1158
Cystometry, 520–523	Ultrasound, prostate, 1158–1160
Cystoscopy, 523–526	Ultrasound, scrotum, 1161–1163
Cystourethrography, voiding, 526–529	Urethrography, retrograde, 1183–1185
Intravenous pyelography, 755–758	

Hematopoietic System**Laboratory Tests Associated with the Hematopoietic System**

δ -Aminolevulinic acid, 41–43	Antithrombin III, 134–136
Anion gap, 83–86	Biopsy, bone marrow, 173–177
Antibodies, cardiolipin, immunoglobulin G and immunoglobulin M, 130, 113–115	Bleeding time, 220
	Blood groups and antibodies, 233–237

(table continues on page 1242)

Laboratory Tests Associated with the Hematopoietic System

Calcium, blood, 259–263	Iron-binding capacity (total), transferrin, and iron saturation, 764–766
Cholesterol, total, 329–333	Kleihauer-Betke test, 772–774
Clot retraction, 336–337	Lactate dehydrogenase and isoenzymes, 775–776
Coagulation factor assays, 338–341	Lead, 789–791
Complete blood count, 360–367	Leukocyte alkaline phosphatase, 795–799
Coombs' antiglobulin, direct, 457–458	Lupus anticoagulant antibodies, 811–813
Coombs' antiglobulin, indirect, 459–460	Methemoglobin, 874–876
Copper, 461–463	Osmotic fragility, 902–903
D-Dimer, 539–541	Partial thromboplastin time, 925–929
Eosinophil count, 572–575	Plasminogen, 945–947
Erythrocyte protoporphyrin, free, 575–577	Platelet antibodies, 948–949
Erythrocyte sedimentation rate, 577–580	Complete Blood Count, Platelet count, 378–382
Erythropoietin, 580–582	Porphyryns, urine, 959–962
Ferritin, 608–610	Protein C, 999–1001
Fibrin degradation products, 617–619	Protein S, 1001–1003
Fibrinogen, 620–622	Prothrombin time and INR, 1007–1011
Folate, 626–628	Pyruvate kinase, 1020
Glucose-6-phosphate dehydrogenase, 662	Red blood cell cholinesterase, 1030–1032
Ham's test for paroxysmal nocturnal hemoglobinuria, 683	Complete Blood Count, RBC count, 383–388
Haptoglobin, 685–687	Complete Blood Count, Red blood cell indices, 388–391
Complete Blood Count, Hematocrit, 365–372	Complete Blood Count, RBC Morphology and Inclusions, 391–396
Complete Blood Count, Hemoglobin, 372–378	Reticulocyte count, 1042–1044
Hemoglobin electrophoresis, 689–691	Sickle cell screen, 1060–1061
Hemosiderin, 691–693	Transferrin, 1106–1108
Homocysteine and methylmalonic acid, 709–711	Vitamin B ₁₂ , 1217–1219
Immunofixation electrophoresis, blood and urine, 731–733	Vitamin E, 1222–1224
Immunoglobulins A, D, G, and M, 735–738	Vitamin K, 1224–1226
International Normalized Ratio (INR), 1007–1011	Complete Blood Count, WBC Count and Differential, 396–403
Intrinsic factor antibodies, 759–760	
Iron, 609–610, 760–764	

Diagnostic Tests Associated with the Hematopoietic System

Angiography, abdomen, 57–61	Meckel's diverticulum scan, 864–867
Computed tomography, spleen, 449–453	Positron emission tomography, fluorodeoxyglucose, 598–601
Gastrointestinal blood loss scan, 651–654	Ultrasound, lymph nodes and retroperitoneum, 1150–1152
Liver and spleen scan, 800–803	Ultrasound, spleen, 1163–1166
Lymphangiography, 818–821	

Hepatobiliary System

Laboratory Tests Associated with the Hepatobiliary System

Acetaminophen, 54–57	Complete Blood Count, Hemoglobin, 372–378
Acetylsalicylic acid, 54–57	Hepatitis A antibody, 693–695
Alanine aminotransferase, 13–15	Hepatitis B antigen and antibody, 695–698
Albumin, 15–18	Hepatitis C antibody, 698–700
Aldolase, 18–19	Hepatitis D antibody, 700
Alkaline phosphatase and isoenzymes, 23–26	Imipramine, 124–128
Amino Acid, blood, 35–38	Infectious mononucleosis screen, 742–744
Amino Acid, urine, (Available at Davis Plus website), 39–41	International Normalized Ratio (INR), 1007–1011
Amityryptiline, 124–128	Lactate dehydrogenase and isoenzymes, 775–776
Ammonia, 43–45	Lactic acid, 776–779
Amylase, 51–53	Lipase, 797–799
Antibodies, antineutrophilic cytoplasmic, 102–104	Nortriptyline, 124–128
Antibodies, Antimitochondrial and Antismooth Muscle, 100–102	Partial thromboplastin time, 925–929
α_1 -Antitrypsin and α_1 -antitrypsin phenotyping, 136–139	Phenobarbital, 117–122
Aspartate aminotransferase, 149–152	Phenytoin, 117–122
Bilirubin and bilirubin fractions, 162–166	Prealbumin, 982–984
Biopsy, liver, 194–197	Primidone, 117–122
Calcium, blood, 259–263	Protein, blood, total and fractions, 995–998
Carbamazepine, 117–122	Protein C, 999–1001
Ceruloplasmin, 295–258	Protein S, 1001–1003
Cholesterol, total, 329–333	Prothrombin time and INR, 1007–1011
Coagulation factor assays, 338–341	Pseudocholinesterase, 1011–1012
Copper, 461–463	Complete Blood Count, RBC count, 383–388
Desipramine, 124–128	Complete Blood Count, RBC Morphology and Inclusions, 363–364, 391–396
Diazepam, 124–128	Urea nitrogen, blood, 1177–1180
Doxepin, 124–128	Uric acid, blood, 1185–1188
Ethosuximide, 117–122	Valproic acid, 117–122
Fibrinogen, 620–622	Vitamin E, 1222–1224
δ -Glutamyltransferase, 669–672	Vitamin K, 1225–1226
Haloperidol, 131–134	Zinc, 1234–1236
Haptoglobin, 685–687	
Complete Blood Count, Hematocrit, 365–372	

Diagnostic Tests Associated with the Hepatobiliary System

Angiography, abdomen, 57–61	Cholangiography, postoperative, 318–321
Cholangiography, percutaneous transhepatic, 314–318	Cholangiopancreatography, endoscopic retrograde, 321–324

(table continues on page 1244)

Diagnostic Tests Associated with the Hepatobiliary System

Computed tomography, angiography, 412–416	Magnetic resonance imaging, abdomen, 832–835
Computed tomography, liver, 412–416	Radiofrequency ablation, liver, 1024–1027
Hepatobiliary scan, 701–704	Ultrasound, liver and biliary system, 1147–1149
Magnetic resonance angiography, 829–831, 836–839	

Immune System**Laboratory Tests Associated with the Immune System**

Acid phosphatase, prostatic, 3–4 (Available at Davis Plus website)	Biopsy, bone marrow, 173–177
Albumin, 15–18	Biopsy, breast, 177–181
Allergen-specific immunoglobulin E, 26–28	Biopsy, cervical, 182–185
Amikacin, 92–96	Biopsy, intestinal, 188–190
Angiotensin-converting enzyme, 82–83	Biopsy, kidney, 191–194
Anion gap, 83–86	Biopsy, liver, 194–197
Antibodies, anticephalomedian, 104–108	Biopsy, lung, 197–201
Antibodies, anti-cyclic citrullinated peptide, 96–98	Biopsy, lymph node, 202–205
Antibodies, antineutrophilic cytoplasmic, 102–104	Biopsy, muscle, 205–208
Antibodies, anti-DNA, 104–108	Biopsy, prostate, 208–211
Antibodies, anti-glomerular basement membrane, 99–100	Biopsy, skin, 212–214
Antibodies, Antimitochondrial and Antismooth Muscle, 100–102	Biopsy, thyroid, 215–217
Antibodies, antinuclear, 104–108	Bladder cancer markers, 218–219
Antibodies, antiscleroderma, 104–108	Blood groups and antibodies, 233–237
Antibodies, antismooth muscle, 100–102	Carcinoembryonic antigen, 282–285
Antibodies, antisperm, 108–110	CD4/CD8 enumeration, 291–293
Antibodies, antistreptolysin O, 110–111	Cerebrospinal fluid analysis, 293–298
Antibodies, antithyroglobin and antithyroid peroxidase, 112–113	<i>Chlamydia</i> group antibody, 304–306
Antibodies, cardiolipin, immunoglobulin G and immunoglobulin M, 113–115	Cold agglutinin titer, 341–343
Antibodies, gliadin (immunoglobulin G and immunoglobulin A), 115–117	Complement C3 and complement C4, 356–358
Antideoxyribonuclease-B, streptococcal, 122–124	Complement, total, 359–360
Antigens/antibodies, antiextractable nuclear, 104–108	Complete blood count, 360–367
Biopsy, bladder, 166–169	Copper, 461–463
Biopsy, bone, 170–172	C-reactive protein, 470–472
	Cryoglobulin, 485–486
	Culture and smear, mycobacteria, 487–492
	Culture, bacterial, anal/genital, ear, eye, skin, and wound, 492–497
	Culture, bacterial, blood, 498–501
	Culture, bacterial, sputum, 501–506
	Culture, bacterial, stool, 506–509
	Culture, bacterial, throat or nasopharyngeal, 509–511
	Culture, bacterial, urine, 511–514

Laboratory Tests Associated with the Immune System

- Culture, fungal, 514–516
 Culture, specific body fluid, 514–516
 Culture, synovial fluid, 1077–1080
 Culture, viral, 517–519
 Cytology, sputum, 527
 Cytology, urine, 534–536
 Cytomegalovirus, immunoglobulin G and immunoglobulin M, 537–538
 Eosinophil count, 572–575
 Erythrocyte sedimentation rate, 577–580
 Estrogen and progesterone receptor antibodies, 178
 α_1 -Fetoprotein, 613–617
 Gentamicin, 92–96
 Gram stain, 677–679
 Haptoglobin, 685–687
Helicobacter pylori antibody, 687–688
 Complete Blood Count, Hematocrit, 365–372
 Complete Blood Count, Hemoglobin, 365–378
 Hepatitis A antibody, 693–695
 Hepatitis B antigen and antibody, 695–698
 Hepatitis C antibody, 698–700
 Hepatitis D antibody, 700 (Available at Davis Plus website)
 Her-2/neu oncoprotein, 178
 Human chorionic gonadotropin, 714–717
 Human immunodeficiency virus type 1 and type 2 antibodies, 715–717
 Human leukocyte antigen B27, 720–722
 Human T-lymphotropic virus type I and type II antibodies, 722–724
 5-Hydroxyindoleacetic acid, 724–726
 Hypersensitivity pneumonitis, 727 (Available at Davis Plus website)
 Immunofixation electrophoresis, blood and urine, 731–733
 Immunoglobulins A, D, G, and M, 735–738
 Infectious mononucleosis screen, 742–744
 Insulin antibodies, 748–749
 Latex allergy, 27–28 (Available at Davis Plus website)
 Leukocyte alkaline phosphatase, 795–797
 Lupus anticoagulant antibodies, 811–813
 Lyme antibody, 816–818
 β_2 -Microglobulin, 878–883
 Mumps serology, 883–885
 Ova and parasites, stool, 603–604, 908–909
 Papanicolaou smear, 915–919
 Parvovirus B19 immunoglobulin G and immunoglobulin M antibody, 929–931
 Pericardial fluid analysis, 931–934
 Peritoneal fluid analysis, 935–938
 Platelet antibodies, 948–949
 Complete Blood Count, Platelet count, 378–382
 Pleural fluid analysis, 954–958
 Potassium, blood, 974–978
 Prostate-specific antigen, 993–995
 Protein, blood, total and fractions, 995–998
 Protein, urine, total quantitative and fractions, 1003–1006
 Complete Blood Count, RBC count, 383–388
 Complete Blood Count, Red blood cell indices, 388–391
 Complete Blood Count, RBC Morphology and Inclusions, 363–364, 391–396
 Rheumatoid factor, 1049–1050
 Rubella, 517–519
 Rubella, 1053–1054
 Streptococcal screen, rapid, 680–681
 Synovial fluid analysis, 1077–1080
 Syphilis serology, 1081–1083
 Tobramycin, 92–96
Toxoplasma antibody, 1104
 Tuberculin skin tests, 1118–1122
 Vancomycin, 92–96
 Varicella, 212–214
 Complete Blood Count, WBC Count and Differential, 365–367, 396–403
 Zinc, 1234–1236

Diagnostic Tests Associated with the Immune System

Gallium scan, 636–638

White blood cell scan, 1231–1233

Musculoskeletal System**Laboratory Tests Associated with the Musculoskeletal System**

Acetylcholine receptor antibody, 1–3	Creatine kinase and isoenzymes, 472–475
Aldolase, 18–19 (Available at Davis Plus website)	Creatinine, blood, 476–479
Alkaline phosphatase and isoenzymes, 23–26	Complete Blood Count, Hematocrit, 365–372
Angiotensin-converting enzyme, 82–83	Complete Blood Count, Hemoglobin, 372–378
Antibodies, anti-cyclic citrullinated peptide, 96–98	Human leukocyte antigen B27, 720–722
Antibodies, antineutrophilic cytoplasmic, 102–104	Immunoglobulins A, D, G, and M, 735–738
Antibodies, antinuclear, anti-DNA, and anticentromere, 104–108	Lactate dehydrogenase and isoenzymes, 773
Antibodies, antiscleroderma, 104–108	Lactic acid, 776–779
Antigens/antibodies, anti-extractable nuclear, 104–108	Lupus anticoagulant antibodies, 811–813
Biopsy, bone, 170–172	Lyme antibody, 816–818
Biopsy, lymph node, 202–205	Myoglobin, 893–895
Biopsy, muscle, 205–208	Osteocalcin, 903–905
Biopsy, skin, 212–214	Phosphorus, blood, 939–942
Calcitonin and calcitonin stimulation tests, 256–259	Pseudocholinesterase and dibucaine number, 1011–1012 (Available at Davis Plus website)
Calcium, blood, 259–263	Rheumatoid factor, 1049–1050
Calcium, urine, 267–271	Synovial fluid analysis, 1077–1080
Cerebrospinal fluid analysis, 293–298	Uric acid, blood, 1185–1188
Collagen cross linked N-telopeptide, 344–346	Vitamin D, 1228
	Zinc, 1234–1236

Diagnostic Tests Associated with the Musculoskeletal System

Alzheimer Disease Markers, 32–34	Computed tomography, spine, 445–449
Arthrogram, 143–146	Electroencephalography, 562–564
Bone mineral density, 242–245	Electromyography, 565–567
Bone scan, 245–248	Electromyography, pelvic floor sphincter, 568–570
Computed tomography, brain, 416–420	

Diagnostic Tests Associated with the Musculoskeletal System

Electroneurography, 570–572	Positron emission tomography, fluorodeoxyglucose, 598–601
Evoked brain potentials, 590–594	Radiography, bone, 1027–1029
Magnetic resonance imaging, musculoskeletal, 847–850	Vertebroplasty, 1211–1214
Positron emission tomography, brain, 962–966	

SYS

Nutritional Considerations**Laboratory Tests with Nutritional Considerations**

Albumin and Albumin/Globulin ratio, 15–18	Magnesium, Blood, 822–824
Calcium, Blood, 259–263	Oxalate, Urine, 910–912
Chloride, Blood, 306–310	Phosphorus, Blood, 939–942
Cholesterol, HDL and LDL, 325–329	Potassium, Blood, 974–978
Cholesterol, Total, 329–333	Sodium, Blood, 1064–1067
Copper, 461–463	Triglycerides, 1108–1111
Folate, 626–628	Uric Acid, Blood, 1185–1188
Glucose, 657–672	Vitamin B ₁₂ , 1217–1219
Insulin and Insulin Response to Glucose, 744–747	Vitamin D, 1220
Iron, 760–766	Vitamin E, 1222–1224
	Vitamin K, 1224–1226
	Vitamins A, B ₁ , B ₆ , and C, 1226–1230

Ocular System**Laboratory Tests Associated with the Ocular System**

Antibodies, Antinuclear, Anti-DNA, Anticentromere, Antiextractable Nuclear Antigen, and Antiscleroderma, 104–108	Culture, Bacterial, Anal/Genital, Ear, Eye, Skin, and Wound, 492–497
Antiarrhythmic Drugs: Digoxin, Disopyramide, Flecainide, Lidocaine, Procainamide, Quinidine, 86–92	Fructosamine, 631–633
Anticonvulsant Drugs: Carbamazepine, Ethosuximide, Phenobarbital, Phenytoin, Primidone, Valproic Acid, 117–122	Glucagon, 654–657
C-Peptide, 467–469	Glucose, 657–676
Cholesterol, Total, 329–333	Glycated Hemoglobin A _{1C} , 672–674
	Insulin and Insulin Response to Glucose, 744–747
	Microalbumin, 876–879
	Plethysmography, 950–954
	Rheumatoid Factor, 1049–1050
	Vitamins A, B ₁ , B ₆ , and C, 1226–1230

Diagnostic Tests Associated with the Ocular System

- Color perception test, 351–352
- Computed Tomography, Brain, 416–420
- Evoked Brain Potentials, 590–594
- Fluorescein angiography, 623–625
- Fundus photography, 633–635
- Gonioscopy, 675–677
- Intraocular muscle function, 750–752
- Intraocular pressure, 752–755
- Magnetic Resonance Imaging, Brain, 836–839
- Magnetic Resonance Imaging, Pituitary, 858–861
- Nerve fiber analysis, 896–898
- Pachymetry, 913–914
- Refraction, 1032–1035
- Schirmer test, 1055–1056
- Slit-lamp biomicroscopy, 1061
- Ultrasound, A-scan, 1131–1133
- Visual field test, 1215–1217

Reproductive System**Laboratory Tests Associated with the Reproductive System**

- Acid phosphatase, prostatic, 3–4
- Amino acid screen, blood, 35–38
- Amino acid screen, urine, 39–41
(Available at Davis Plus website)
- Amniotic fluid analysis, 45–51
- Amniotic fluid index, 1135
- Antibodies, antisperm, 108–110
- Antibodies, cardiolipin, immunoglobulin G and immunoglobulin M, 113–115
- Biopsy, breast, 177–181
- Biopsy, cervical, 182–185
- Biopsy, chorionic villus, 185–188
- Biopsy, prostate, 208–211
- Carcinoembryonic antigen, 282–285
- Chlamydia* group antibody, 304–306
- Chromosome analysis, blood, 333–336
- Collagen cross-linked N-telopeptide, 344–346
- Contraction stress test, 1135
- Culture, bacterial, anal/genital, 492–497
- Culture, viral, 517–519
- Cytomegalovirus, immunoglobulin G and immunoglobulin M, 537–538
- Estradiol, 589–590 (Available at Davis Plus website)
- Estrogen and progesterone receptor antibodies, 178
- Fern Test, 46
- Fetal fibronectin, 611–612
- α_1 -Fetoprotein, 613–617
- Follicle-stimulating hormone, 628–631
- Her-2/neu oncoprotein, 178
- Hexosaminidase A and B, 704–706
- Human chorionic gonadotropin, 714–717
- Human immunodeficiency virus type 1 and type 2 antibodies, 715–717
- Human papillomavirus, 915–916
- Inhibin-A, 614
- Ki67, 178
- Kleihauer-Betke test, 772–774
- Lecithin/sphingomyelin ratio, 791–795
- Lupus anticoagulant antibodies, 811–813
- Luteinizing hormone, 813–816
- Nonstress test, 1134
- Magnesium, blood, 822–824
- P53, 178
- Papanicolaou smear, 915–919
- Placental microglobulin 1 protein, 47
- Proliferating cell nuclear antigen, 178
- Progesterone, 988–990
- Prolactin, 990–993
- Prostate-specific antigen, 993–995
- Rubella, 517–519, 1051–1053
- Rubeola, 1053–1054
- S phase fraction, 178
- Semen analysis, 1057–1059
- Syphilis serology, 1081–1083
- Testosterone, total, 1084–1086
- Toxoplasma* antibody, 1104
- Urinalysis, 1192–1199
- Varicella, 212–214

Diagnostic Tests Associated with the Reproductive System

Colposcopy, 353–355	Positron emission tomography, fluorodeoxyglucose, 598–601
Computed tomography, pelvis, 433–437	Positron emission tomography, pelvis, 970–973
Hysterosalpingography, 727–730	Sterotactic biopsy, breast, 1074–1077
Laparoscopy, abdominal, 782–785	Ultrasound, biophysical profile, obstetric, 1134–1139
Laparoscopy, gynecologic, 785–788	Ultrasound, pelvic, 1155–1158
Magnetic resonance imaging, breast, 839–843	Ultrasound, scrotal, 1161–1163
Magnetic resonance imaging, pelvis, 854–857	Uterine fibroid embolization, 1199–1202
Mammography, 861–864	

SYS

Respiratory System**Laboratory Tests Associated with the Respiratory System**

Allergen-specific immunoglobulin E, 26–28	Eosinophil count, 572–575
Alveolar/arterial gradient and arterial/alveolar oxygen ratio, 29–32	Erythrocyte sedimentation rate, 577–580
Angiotensin-converting enzyme, 82–83	Fecal fat, 605–608
Anion gap, 83–86	Gram stain, 677–679
Antibodies, anti-glomerular basement membrane, 99–100	Complete Blood Count, Hematocrit, 365–372
α_1 -Antitrypsin and α_1 -antitrypsin phenotyping, 136–139	Complete Blood Count, Hemoglobin, 372–378
Biopsy, lung, 197–201	Hypersensitivity pneumonitis, 727 (Available at Davis Plus website)
Blood gases, 221–232	Immunoglobulin E, 733–735
Carbon dioxide, 276–279	Lactic acid, 776–779
Carboxyhemoglobin, 280–282	Lecithin/sphingomyelin ratio, 791–795
Chloride, blood, 306–310	Pleural fluid analysis, 954–958
Chloride, sweat, 310–314	Potassium, blood, 974–978
Cold agglutinin titer, 341–343	Rapid streptococcal screen, 680–681
Complete blood count, 360–367	Complete Blood Count, RBC count, 383–388
Culture and smear, mycobacteria, 487–492	Complete Blood Count, Red blood cell indices, 363
Culture, bacterial, sputum, 501–506	Tuberculin skin tests, 1118–1122
Culture, bacterial, throat, 509–511	Complete Blood Count, WBC Count and Differential, 396–403
Culture, viral, 517–519	
Cytology, sputum, 527	
D-Dimer, 539–541	

Diagnostic Tests Associated with the Respiratory System

Angiography, pulmonary, 74–77	Magnetic resonance imaging, chest, 843–846
Bronchoscopy, 249–253	Mediastinoscopy, 868–871
Chest x-ray, 301–303	Pulmonary function studies, 1012–1017
Computed tomography, chest, 421–424	Pulse oximetry, 1018–1020
Lung perfusion scan, 804–807	
Lung ventilation scan, 807–810	

SYS

Therapeutic Drug Monitoring and Toxicology**Laboratory Tests Associated with Therapeutic Drug Monitoring and Toxicology**

Acetaminophen, 54–57	Flecainide, 86–92
Acetylsalicylic acid, 54–57	Gentamicin, 92–96
Albumin, 15–18	Haloperidol, 131–134
Alcohol, ethyl, 544–547	Imipramine, 124–128
Amikacin, 92–96	Lead, 789–791
Amitriptyline, 124–128	Lidocaine, 86–92
Amphetamines, 544–547	Lithium, 131–134
Barbiturates, 544–577	Methotrexate, 739–742
Benzodiazepines, 544–547	Nortriptyline, 124–128
Cannabinoids, 544–547	Opiates, 544–547
Carbamazepine, 117–122	Phencyclidine, 544–547
Cocaine, 544–547	Phenobarbital, 117–122
Cyclosporine, 739–742	Phenytoin, 117–122
Desipramine, 124–128	Primidone, 117–122
Diazepam, 544–547	Procainamide, 86–92
Digoxin, 86–92	Quinidine, 86–92
Disopyramide, 86–92	Tobramycin, 92–96
Doxepin, 124–128	Tricyclic antidepressants, 133–134
Ethanol, 380–382	Valproic acid, 117–122
Ethosuximide, 117–122	Vancomycin, 92–96

Patient Preparation and Specimen Collection

PATIENT PREPARATION BEFORE DIAGNOSTIC AND LABORATORY PROCEDURES

The first step in any laboratory or diagnostic procedure is patient preparation or patient teaching before the performance of the procedure. This pretesting explanation to the patient or caregiver follows essentially the same pattern for all sites and types of studies and includes the following:

- *Statement of the purpose of the study.* The level of detail provided to patients about the test purpose depends on numerous factors and should be individualized appropriately in each particular setting.
- *Description of the procedure, including site and method.* It is a good idea to explain to the patient that you will be wearing gloves throughout the procedure. The explanation should help the patient understand that the use of gloves is standard practice established for his or her protection as well as yours. Many institutions require hand washing at the beginning and end of each specimen collection encounter and between each patient.
- *Description of the sensations, including discomfort and pain, that the patient may experience during the specimen collection procedure.* Address concerns about pain related to the procedure and suggest breathing or visualization techniques to promote relaxation. For pediatric patients, a doll may be used to “show” the procedure. Where appropriate, the use of sedative or anesthetizing agents may assist in allaying anxiety the patient may experience that is related to anticipation of pain associated with the procedure. Sensitivity to cultural and social issues, as well as concern for modesty, is important in providing psychological support.
- *Instruction regarding pretesting preparations related to diet, liquids, medications, and activity as well as any restrictions regarding diet, liquids, medications, activity, known allergies, therapies, or other procedures that might affect test results.* To increase patient compliance, the instructions should include an explanation of why strict adherence to the instructions is required.
- *Recognition of anxiety related to test results.* Provide a compassionate, reassuring environment. Be prepared to educate the patient regarding access to the appropriate counseling services. Encourage the patient to ask questions and verbalize his or her concerns.

Specific collection techniques and patient preparation vary by site, study required, and level of invasiveness. These techniques are described in the individual monographs.

- It is essential that the patient be positively and properly identified before providing care, treatment, or services. Specimens should always be labeled with the patient’s name, date of birth, (or some other unique identifier), date collected, time collected, and initials of the person collecting the sample.
- Orders should be completed accurately and submitted per laboratory policy.

BLOOD SPECIMENS

Most laboratory tests that require a blood specimen use venous blood. Venous blood can be collected directly from the vein or by way of capillary puncture. Capillary blood can be obtained from the fingertips or earlobes of

adults and small children. Capillary blood can also be obtained from the heels of infants. The circumstances in which the capillary method would be selected over direct venipuncture include cases in which:

- The patient has poor veins.
- The patient has small veins.
- The patient has a limited number of available veins.
- The patient has significant anxiety about the venipuncture procedure.

Venous blood also can be obtained from vascular access devices, such as heparin locks and central venous catheters. Examples of central venous catheters include the triple-lumen subclavian, Hickman, and Groshong catheters.

Fetal blood samples can be obtained, when warranted, by a qualified health care provider (HCP) from the scalp or from the umbilical cord.

Arterial blood can be collected from the radial, brachial, or femoral artery if blood gas analysis is requested.

There are some general guidelines to be followed should follow in the procurement and handling of blood specimens:

- The practice of an overnight fast before specimen collection is a general recommendation. Reference ranges are often based on fasting populations to provide some level of standardization for comparison. Some test results are dramatically affected by foods, however, and fasting is a pretest requirement. The presence of lipids in the blood also may interfere with the test method; fasting eliminates this potential source of error, especially if the patient already has elevated lipid levels. The laboratory should always be consulted if there is a question as to whether fasting is a requirement or a recommendation.
- Gloves and any other additional personal protective equipment indicated by the patient's condition should always be worn during the specimen collection process. Appendix G can be consulted for a more detailed description of standard precautions.
- Stress can cause variations in some test results. A sleeping patient should be gently awakened and allowed the opportunity to become oriented before collection site selection. Comatose or unconscious patients should be greeted in the same gentle manner because, although they are unable to respond, they may be capable of hearing and understanding. Anticipate instances in which patient cooperation may be an issue. Enlist the assistance of a second person to assist with specimen collection to ensure a safe, quality collection experience for all involved.
- Localized activity such as the application of a tourniquet or clenching the hand to assist in visualizing the vein can cause variations in some test results. It is important to be aware of affected studies before specimen collection.
- Hemoconcentration may cause variations in some test results. The tourniquet should never be left in place for longer than 1 minute.
- Previous puncture sites should be avoided when accessing a blood vessel by any means, to reduce the potential for infection.
- Specimens should never be collected above an IV line because of the potential for dilution when the specimen and the IV solution combine in the collection container, falsely decreasing the result. It is also possible that substances in the IV solution could contaminate the specimen and result in falsely elevated test results.

- Changes in posture from supine to erect or long-term maintenance of a supine posture causes variations in some test results. It is important to be aware of this effect when results are interpreted and compared with previous values.
- Collection times for therapeutic drug (peak and trough) or other specific monitoring (e.g., chemotherapy, glucose, insulin, or potassium) should be documented carefully in relation to the time of medication administration. It is essential that this information be communicated clearly and accurately to avoid misunderstanding of the dose time in relation to the collection time. Miscommunication between the individual administering the medication and the individual collecting the specimen is the most frequent cause of subtherapeutic levels, toxic levels, and misleading information used in the calculation of future therapies.
- The laboratory should be consulted regarding minimum specimen collection requirements when multiple tube types or samples are required. The amount of serum or plasma collected can be estimated using assumptions of packed cell volume or hematocrit. The packed cell volume of a healthy woman is usually 38% to 44% of the total blood volume. If a full 5-mL red-top tube is collected, and the hematocrit is 38% to 44%, approximately 2.8 to 3.1 mL, or $[5 - (5 \times 0.44)]$ to $[5 - (5 \times 0.38)]$, of the total blood volume should be serum. Factors that invalidate estimation include conditions such as anemia, polycythemia, dehydration, or overhydration.
- The laboratory should be consulted regarding the preferred specimen container before specimen collection. Specific analytes may vary in concentration depending on whether the sample is serum or plasma. It is strongly recommended that, when serial measurements are to be carried out, the same type of collection container be used so that fluctuations in values caused by variations in specimen type are not misinterpreted as changes in clinical status. Consultation regarding collection containers is also important because some laboratory methods are optimized for a specific specimen type (serum versus plasma). Also, preservatives present in collection containers, such as sodium fluoride, may exhibit a chemical interference with test reagents that can cause underestimation or overestimation of measured values. Other preservatives, such as EDTA, can block the analyte of interest in the sample from participating in the test reaction, invalidating test results. Finally, it is possible that some high-throughput, robotic equipment systems require specific and standardized collection containers.
- Prompt and proper specimen processing, storage, and analysis are important to achieve accurate results. Specimens collected in containers with solid or liquid preservatives or with gel separators should be mixed by inverting the tube 10 times immediately after the tube has been filled. Handle the specimen gently to avoid hemolysis. Specimens should always be transported to the laboratory as quickly as possible after collection.

Results that are evaluated outside the entire context of the preparatory, collection, and handling process may be interpreted erroneously if consideration is not given to the above-listed general guidelines.

Site Selection

Capillary Puncture: Assess the selected area. It should be free of lesions and calluses, there should be no edema, and the site should feel warm. If the site

feels cool or if the site appears pale or cyanotic, warm compresses can be applied over 3 to 5 min to dilate the capillaries. For finger sticks, the central, fleshy, distal portions of the third or fourth fingers are the preferred collection sites (Figure Appendix A-1). For neonatal heel sticks, the medial and lateral surfaces of the plantar area are preferred to avoid direct puncture of the heel bone, which could result in osteomyelitis (Figure Appendix A-2).

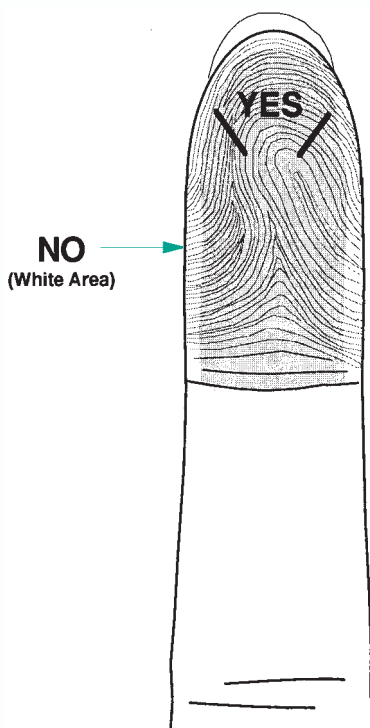


Figure A-1 Site selection. Capillary puncture of the finger.

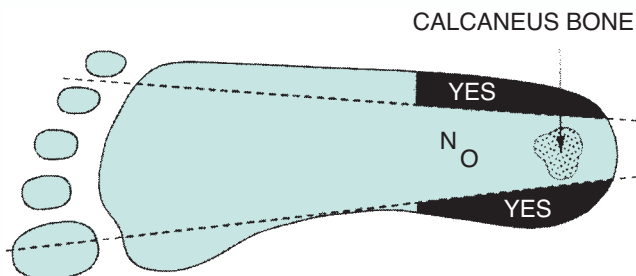


Figure A-2 Site selection. Capillary puncture of the heel.

Venipuncture of Arm: Assess the arm for visibly accessible veins. The selected area should not be burned or scarred, have a tattoo, or have hematoma present. Even after the tourniquet is applied, not all patients have a prominent median cubital, cephalic, or basilic vein. Both arms should be observed because some patients have accessible veins in one arm and not the other. The median cubital vein in the antecubital fossa is the preferred venipuncture site. The patient may be able to provide the best information regarding venous access if he or she has had previous venipuncture experience (Figure Appendix A-3). Alternative techniques to increase visibility of veins may include warming the arm, allowing the arm to dangle downward for a minute or two, tapping the antecubital area with the index finger, or massaging the arm upward from wrist to elbow. The condition of the vein also should be assessed before venipuncture. Sclerotic (hard, scarred) veins or veins in which phlebitis previously occurred should be avoided. Arms with a functioning hemodialysis access site should not be used. The arm on the affected side of a mastectomy should be avoided. In the case of a double mastectomy, the requesting HCP should be consulted before specimen collection.

Venipuncture of Hand and Wrist: If no veins in the arms are available, hands and wrists should be examined as described for the arm (Figure Appendix A-3). Consideration should be given to the venipuncture equipment selected because the veins in these areas are much smaller. Pediatric-sized collection containers and needles with a larger gauge may be more appropriate.

Venipuncture of Legs and Feet: The veins in the legs and feet can be accessed as with sites located on the arm, hand, or wrist. These extremities should be used only on the approval of the requesting HCP because veins in these locations are more prone to infection and formation of blood clots, especially in patients with diabetes, cardiac disease, and bleeding disorders.

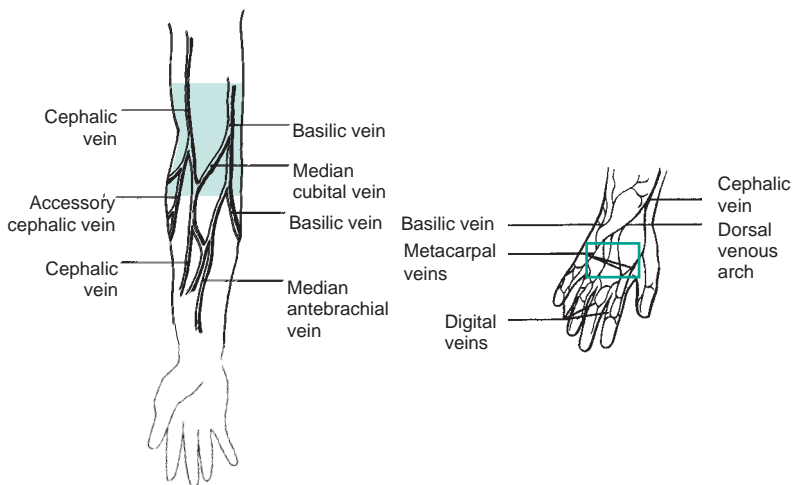


Figure A-3 Site selection. Venipuncture arm/hand.

Radial Arterial Puncture: The radial artery is the artery of choice for obtaining arterial blood gas specimens because it is close to the surface of the wrist and does not require a deep puncture. Its easy access also allows for more effective compression after the needle has been removed. The nearby ulnar artery can provide sufficient collateral circulation to the hand during specimen collection and postcollection compression (Figure Appendix A-4).

Percutaneous Umbilical Cord Sampling: The blood is aspirated from the umbilical cord under the guidance of ultrasonography and using a 20- or 22-gauge spinal needle inserted through the mother's abdomen.

Postnatal Umbilical Cord Sampling: The blood is aspirated from the umbilical cord using a 20- or 22-gauge needle and transferred to the appropriate collection container.

Fetal Scalp Sampling: The requesting HCP makes a puncture in the fetal scalp using a microblade, and the specimen is collected in a long capillary tube. The tube is usually capped on both ends immediately after specimen collection.

Locks and Catheters: These devices are sometimes inserted to provide a means for the administration of fluids or medications and to obtain blood specimens without the need for frequent venipuncture. The device first should be assessed for patency. The need for heparinization, irrigation, or clot removal depends on the type of device in use and the institution-specific or HCP-specific protocols in effect. Use sterile technique because these devices provide direct access to the patient's bloodstream. When IV fluids are being administered via a device at the time of specimen collection, blood should be

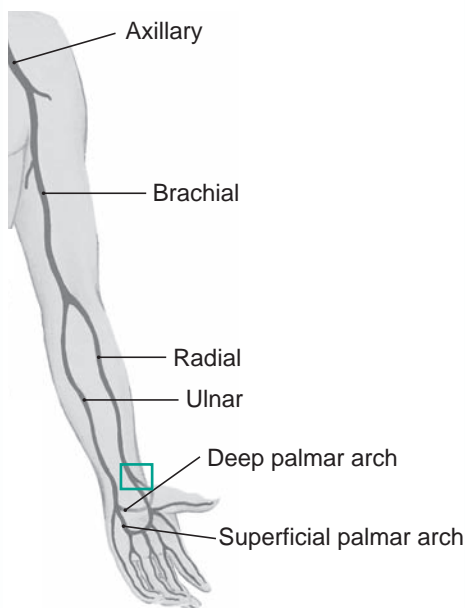


Figure A-4 Site selection. Arterial arm/hand.

obtained from the opposite side of the body. If this is not possible, the flow should be stopped for 5 min before specimen collection. The first 5 mL of blood collected should be discarded.

Selection of Blood Collection Equipment

In many cases when a blood sample is required, serum is the specimen type of choice. Plasma may be frequently substituted, however. Specimen processing is more rapid for plasma samples than serum samples because the anticoagulated sample does not need to clot before centrifugation. Plasma samples also require less centrifugation time to achieve adequate separation. Consult with the testing laboratory regarding recommended specimen types. The basic blood collection tubes are shown on the inside cover of this book. Consider latex allergy when selecting the collection equipment appropriate for each patient. Equipment used in specimen collection includes:

- Gloves and other personal protective equipment depending on the situation
- Tourniquet
- Materials to cleanse or disinfect the collection site (alcohol preparations [70% alcohol], povidone-iodine solution [Betadine], or green soap are the most commonly used materials)
- Gauze (to wipe collection site dry after cleansing)
- Sterile lancet (capillary puncture)
- Syringe and needle (arterial puncture or venipuncture)
- Vial of heparin and syringe or heparin unit dose
- Sterile normal saline in 50-mL syringe (for indwelling devices such as Groshong catheter)
- Sterile cap or hub (for indwelling devices when the cap or hub will be replaced after specimen procurement)
- Needle and holder for vacuumized collection tube system (arterial puncture or venipuncture)
- Butterfly or winged infusion set (venipuncture)
- Collection container (vacuumized collection tube, capillary tube, or Microtainer)
- Bandage (to cover puncture site after specimen collection)

Collection Procedure

The procedures outlined here are basic in description. A phlebotomy or other text should be consulted for specific details regarding specimen collection and complications encountered during various types of blood collection. Positively identify the patient using at least two unique identifiers before providing care, treatment, or services. Label the appropriate tubes with the corresponding patient demographics, date, and time of collection before the specimen is collected. Obtain a history of the patient's complaints, including a list of known allergens, especially allergies or sensitivities to latex.

Capillary: Place the patient in a comfortable position either sitting or lying down. Positively identify the patient using at least two unique identifiers before providing care, treatment, or services. Label the appropriate tubes with the corresponding patient demographics, date, and time of collection before the specimen is collected. Assess whether the patient has allergies to the disinfectant or to latex if latex gloves or tourniquet will be used in the collection procedure. Use gloved hands to select the collection site as

described in the site selection section. Cleanse the skin with the appropriate disinfectant and dry the area. Pull the skin tight by the thumb and index finger of the nondominant hand on either side of the puncture site and move them in opposite directions. Puncture the skin with a sterile lancet to a depth of approximately 2 mm, using a quick, firm motion. Wipe the first drop of blood away using the gauze. If flow is poor, the site should not be squeezed or the specimen may become contaminated with tissue fluid. Do not allow the collection container to touch the puncture site. Collect the sample in the capillary tube or Microtainer. The capillary tube should be held in a horizontal position to avoid the introduction of air bubbles into the sample. Microtainer tubes should be held in a downward-slanted direction to facilitate the flow of blood into the capillary scoop of the collection device. If a smear is required, allow a drop of blood to fall onto a clean microscope slide. Gently spread the drop across the slide using the edge of another slide. Apply slight pressure to the puncture site with a clean piece of gauze until bleeding stops, and then apply a bandage. Safely dispose of the sharps. Transport properly labeled specimens immediately to the laboratory.

Venipuncture Using a Syringe or Vacuumized Needle and Holder System: Place the patient in a comfortable position either sitting or lying down. Positively identify the patient using at least two unique identifiers before providing care, treatment, or services. Label the appropriate tubes with the corresponding patient demographics, date, and time of collection before the specimen is collected. Assess whether the patient has allergies to the disinfectant or to latex if latex gloves or tourniquet will be used in the collection procedure. Use gloved hands to select the collection site as described in the Site Selection section. Locate the vein visually, then by palpation using the index finger. The thumb should not be used because it has a pulse beat and may cause confusion in site selection or in differentiating a vein from an artery. Select the appropriate collection materials (needle size, butterfly, syringe, collection container size) based on the vein size, vein depth, appearance of the collection site, patient's age, and anticipated level of cooperation. Cleanse the skin with the appropriate disinfectant and dry the area. Select the appropriate collection tubes. If blood cultures are to be collected, disinfect the top of the collection containers as directed by the testing laboratory. Be sure to have extra tubes within easy reach in case the vacuum in a collection tube is lost and a substitute is required. Apply the tourniquet 3 to 4 in. above the selected collection site. Remove the sterile needle cap, and inspect the tip of the needle for defects. Pull the skin tight by placing the thumb of the nondominant hand 1 or 2 in. below the puncture site and moving the thumb in the opposite direction. The thumb is placed below the puncture site to help avoid an accidental needle stick if the patient moves suddenly. Ensure that the needle is bevel up and held at an angle of approximately 15° to 30° (depending on the depth of the vein) (Figure Appendix A-5).

Puncture the skin with smooth, firm motion using a sterile needle held by the dominant hand. A reduction in pressure is achieved when the needle has penetrated the vein successfully. Be sure to release the tourniquet within 1 min of application. Fill the vacuumized collection containers in the prescribed order of draw for the studies ordered. Tubes with anticoagulants can be gently mixed with the free nondominant hand as they are filled. When the required containers have been filled, withdraw the needle and apply pressure to the collection site until the bleeding stops. In most cases, a piece of gauze can be placed on the collection site and the arm bent upward to hold it in

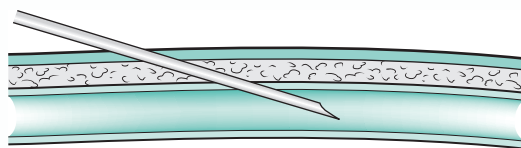


Figure A-5 Venipuncture needle placement at insertion.

place while attention is given to disposing of the sharps safely. In cases in which a syringe is used, the barrel of the syringe should be gently pulled back during specimen collection and gently pushed in during the transfer to collection tubes. The vacuum in the collection container should not be allowed to suck the sample into the container, but rather the speed of entry should be controlled by the pressure applied to the barrel. The blood should gently roll down the side of the tube to prevent hemolysis. Transport properly labeled specimens immediately to the laboratory.

APP

Radial Artery Puncture: Place the patient in a comfortable position either sitting or lying down. Positively identify the patient using at least two unique identifiers before providing care, treatment, or services. Label the appropriate tubes with the corresponding patient demographics, date, and time of collection before the specimen is collected. Assess whether the patient has allergies to the disinfectant or to latex if latex gloves or tourniquet will be used in the collection procedure. Assess if the patient has an allergy to local anesthetics, and inform the HCP accordingly. Glove the hands, and select the collection site as described in the site selection section. Ensure that the patient has adequate collateral circulation to the hand if thrombosis of the radial artery occurs after arterial puncture by performing an Allen test before puncture. The Allen test is performed by occlusion of the ulnar and radial arteries on the palmar surface of the wrist with two fingers. The thumb should not be used to locate these arteries because it has a pulse. Compress both arteries, and ask the patient to open and close the fist several times until the palm turns pale. Release pressure only on the ulnar artery. Color should return to the palm within 5 sec if the ulnar artery is functioning. If coloring returns above the wrist, the Allen test is positive. The Allen test also should be performed on the opposite hand. The wrist to which color is restored fastest has better circulation and should be selected as the site for blood gas collection. Be sure to explain to the patient that an arterial puncture is painful. The site may be anesthetized with 1% to 2% lidocaine (Xylocaine) before puncture. The index finger of the nondominant hand is placed over the site where the needle will enter the artery, not the site where the needle will penetrate the skin. The specimen is collected in an air-free heparinized syringe, which is held like a dart in the dominant hand and inserted slowly, bevel up, about 5 to 10 mm below the palpating finger at a 45° to 60° angle. When blood enters the needle hub, arterial pressure should cause blood to pump into the syringe. When enough specimen has been collected, the needle is withdrawn from the arm, and pressure is applied to the collection site for a minimum of 5 to 10 min. Immediately after the needle has been withdrawn safely from the arm, the exposed end of the syringe should be stoppered.

Samples should be gently and well mixed to ensure proper mixing of the heparin with the sample. The heparin prevents formation of small clots that result in rejection of the sample. The tightly capped sample should be placed in an ice slurry immediately after collection. Information on the specimen

label should be protected from water in the ice slurry by first placing the specimen in a protective plastic bag. Transport properly labeled specimens immediately to the laboratory.

Indwelling Devices: Positively identify the patient using at least two unique identifiers before providing care, treatment, or services. Label the appropriate tubes with the corresponding patient demographics, date, and time of collection before the specimen is collected. Indwelling devices are either heparinized or irrigated after specimen collection. Before specimen collection, prepare the heparin in a syringe, if required. Allow the heparin (unit dose or prepared solution in the syringe) to equilibrate at room temperature during specimen collection. Cleanse the catheter cap or hub with povidone-iodine and 70% alcohol over 2 minutes. Using sterile gloves, remove the cap and attach a 5- or 10-mL syringe to the connector. Withdraw 5 mL of blood to be discarded. Clamp the catheter. (The Groshong catheter does not require clamping because it has a special valve that eliminates the need for clamping.) Attach another 5- or 10-mL syringe and begin collecting blood for transfer to the collection tubes. After the required specimen has been withdrawn, the device is heparinized by slowly injecting the heparin into the cap or hub of the device. Clamp the device 2 in. from the cap, remove the needle, and unclamp the device. Attach a new sterile cap or hub if the old one has been discarded. Groshong catheters are irrigated rather than heparinized. Irrigation of a Groshong catheter is accomplished by gently injecting 20 to 30 mL of sterile normal saline through the cap with moderate force. Remove the needle using some positive pressure (pressing down on the plunger) to prevent the solution from backing up into the syringe. Transport properly labeled specimens immediately to the laboratory.

Order of Draw for Glass or Plastic Tubes (Reflects 2004 change in CLSI [formerly NCCLS] guideline: Recommended Order of Draw, H3-A5, [Vol 23, No 32, 8.10.2])

Note: Always follow your facility's protocol for order of draw.

- First—Blood culture and other tests requiring sterile specimen (yellow or yellow/black stopper); blood culture bottle first, followed by sodium polyethanol sulfonate (SPS) tube for acid-fast bacilli specimens.
- Second—Coagulation studies (light blue [sodium citrate] stopper); sodium citrate forms calcium salts to remove calcium, and this prevents specimen clotting. *Note:* When using a winged blood or vacutainer collection set and the blue-top tube is the first tube drawn, a nonadditive red-top or coagulation discard tube should be collected first and discarded. The amount of blood in the discard tube needs to be sufficient to fill the winged collection set tubing's "dead space" or fill 1/4 of the discard tube. This is done to eliminate contamination of the specimen with tissue thromboplastin. The blue-top tube to be used for testing must be filled to ensure the proper ratio of blood to additive in the test specimen blue-top tube.
- Third—Plain or nonadditive (red or red/gray [gel] stopper); red/gray-top serum separator tube (SST) contains a gel separator and clot activator. SSTs are not appropriate for all testing requiring a serum specimen. They are generally unacceptable for therapeutic drug monitoring and serology studies. The laboratory should be consulted if there are questions regarding the use of SSTs.
- Last—Additive tubes in the following order:

Green stopper: tube contains sodium heparin or lithium heparin anticoagulant (heparin inactivates thrombin and thromboplastin, and this prevents specimen clotting). For ammonia levels, use sodium or lithium heparin. For lithium levels, use sodium heparin.

Lavender stopper: tube contains K₂EDTA (tri-potassium EDTA forms calcium salts to remove calcium from the sample, and this prevents specimen clotting while preserving the integrity of the red blood cell wall).

Gray stopper: tube contains potassium oxalate/sodium fluoride (the potassium oxalate acts as an anticoagulant, and the sodium fluoride prevents glycolysis).

URINE SPECIMENS

The patient should be informed that improper collection, storage, and transport are the primary reasons for specimen rejection and subsequent requests for recollection. If the specimen is to be collected at home, it should be collected in a clean plastic container (preferably a container from the testing laboratory). Many studies require refrigeration after collection. If the collection container includes a preservative, the patient should be made aware of the contents and advised as to what the precaution labels mean (caution labels such as caustic, corrosive, acid, and base should be affixed to the container as appropriate). When a preservative or fixative is included in the container, the patient should be advised not to remove it. The patient also should be told not to void directly into the container. The patient should be given a collection device, if indicated, and instructed to void into the collection device. The specimen should be carefully transferred into the collection container. Urinary output should be recorded throughout the collection time if the specimen is being collected over a specified time interval. Some laboratories provide preprinted collection instructions tailored to their methods. The specimen should be transported promptly to the laboratory after collection.

Wear gloves and any other additional personal protective equipment indicated by the patient's condition. See Appendix G for a more detailed description of standard precautions. Assess whether the patient has allergies to the disinfectant or anesthetic, or to latex if latex gloves or catheter will be used in the procedure.

Random: These samples are mainly used for routine screening and can be collected at any time of the day. The patient should be instructed to void either directly into the collection container (if there is no preservative) or into a collection device for transfer into the specimen container.

First Morning: Urine on rising in the morning is very concentrated. These specimens are indicated when screening for substances that may not be detectable in a more dilute random sample. These specimens are also necessary for testing conditions such as orthostatic proteinuria, in which levels vary with changes in posture.

Second Void: In some cases, it is desirable to test freshly produced urine to evaluate the patient's current status, as with glucose and ketones. Explain to the patient that he or she should first void and then drink a glass of water. The patient should be instructed to wait 30 min and then void either directly into the collection container or into a collection device for transfer into the collection container.

Clean Catch: These midstream specimens are generally used for microbiological or cytological studies. They also may be requested for routine urinalysis to provide a specimen that is least contaminated with urethral cells, microorganisms, mucus, or other substances that may affect the interpretation of results. Instruct the male patient first to wash hands thoroughly, then cleanse the meatus, void a small amount into the toilet, and void either directly into the specimen container or into a collection device for transfer into the specimen container. Instruct the female patient first to wash hands thoroughly, and then to cleanse the labia from front to back. While keeping the labia separated, the patient should void a small amount into the toilet, and then, without interrupting the urine stream, void either directly into the specimen container or into a collection device for transfer into the specimen container.

Catheterized Random or Clean Catch: “Straight catheterization” is indicated when the patient is unable to void, when the patient is unable to prepare properly for clean-catch specimen collection, or when the patient has an indwelling catheter in place from which a urine sample may be obtained. Before collecting a specimen from the catheter, observe the drainage tube to ensure that it is empty, and then clamp the tube distal to the collection port 15 min before specimen collection. Cleanse the port with an antiseptic swab such as 70% alcohol and allow the port to dry. Use a needle and syringe (sterile if indicated) to withdraw the required amount of specimen. Unclamp the tube.

Timed: To quantify substances in urine, 24-hr urine collections are used. They are also used to measure substances whose level of excretion varies over time. The use of preservatives and the handling of specimens during the timed collection may be subject to variability among laboratories. The testing laboratory should be consulted regarding specific instructions before starting the test. Many times the specimen must be refrigerated or kept on ice throughout the entire collection period. Explain to the patient that it is crucial for *all* urine to be included in the collection. Urinary output should be recorded throughout the collection time if the specimen is being collected over a specified time interval. The test should begin between 6 and 8 a.m., if possible. Instruct the patient to collect the first void of the day and discard it. The start time of the collection period begins at the time the first voided specimen was discarded and should be recorded along with the date on the collection container. The patient should be instructed to void at the same time the following morning and to add this last voiding to the container. This is the end time of the collection and should be recorded along with the date on the container. For patients who are in the hospital, the urinary output should be compared with the volume measured in the completed collection container. Discrepancies between the two volumes indicate that a collection might have been discarded. Many times a creatinine level is requested along with the study of interest to evaluate the completeness of the collection.

Catheterized Timed: Instructions for this type of collection are basically the same as those for timed specimen collection. The test should begin by changing the tubing and drainage bag. If a preservative is required, it can be placed directly in the drainage bag, or the specimen can be removed at frequent intervals (every 2 hr) and transferred to the collection container to which the preservative has been added. The drainage bag must be kept on ice or emptied periodically into the collection container during the entire collection

period if indicated by the testing laboratory. The tubing should be monitored throughout the collection period to ensure continued drainage.

Suprapubic Aspiration: This procedure is performed by inserting a needle directly into the bladder. Because the bladder is normally sterile, the urine collected should also be free from any contamination caused by the presence of microorganisms. Place the patient in a supine position. Cleanse the area with antiseptic and drape with sterile drapes. A local anesthetic may be administered before insertion of the needle. A needle is inserted through the skin into the bladder. A syringe attached to the needle is used to aspirate the urine sample. The needle is then removed and a sterile dressing is applied to the site. Place the sterile sample in a sterile specimen container. The site must be observed for signs of inflammation or infection.

Pediatric: Specimen collection can be achieved by any of the above-described methods using collection devices specifically designed for pediatric patients. Appropriately cleanse the genital area and allow the area to dry. For a random collection, remove the covering of the adhesive strips on the collector bag and apply over the genital area. Diaper the child. When the specimen is obtained, place the entire collection bag in the specimen container (use a sterile container as appropriate for the requested study). Some laboratories may have specific preferences for the submission of urine specimens for culture. Consult the laboratory before collection to avoid specimen rejection.

BODY FLUID, STOOL, AND TISSUE

Wear gloves and any other additional personal protective equipment indicated by the patient's condition. See Appendix G for a more detailed description of standard precautions. Assess whether the patient has allergies to the disinfectant, anesthetic, or to latex if latex gloves will be used in the procedure.

Specific collection techniques vary by site, study required, and level of invasiveness. These techniques are described in the individual monographs.

DIAGNOSTIC TESTING

Wear gloves and any other additional personal protective equipment indicated by the patient's condition. See Appendix G for a more detailed description of standard precautions. Assess whether the patient has allergies to the disinfectant, anesthetic, contrast material, or medications, or to latex if latex gloves, catheter, or tourniquet will be used in the procedure.

A sleeping patient should be gently awakened and allowed the opportunity to become oriented before preparation for the selected study. Comatose or unconscious patients should be greeted in the same gentle manner because, although they are unable to respond, they may be capable of hearing and understanding. Anticipate instances in which patient cooperation may be an issue. Enlist the assistance of a second person to help with preparing the patient for the procedure to ensure a safe, quality testing experience for all involved.

Specific techniques and patient preparation vary by site, study required, and level of invasiveness. These techniques are described in the individual monographs.

Appendix B

Potential Nursing Diagnoses Associated with Laboratory and Diagnostic Testing

PRETEST PHASE

Anxiety related to undiagnosed health problems

Anxiety related to perceived threat to health status

Anxiety and fear related to anticipated diagnostic results

Anxiety and fear related to perception of diagnostic procedure as frightening or embarrassing

Powerlessness related to unfamiliar procedure, equipment, environment, or personnel

Knowledge deficit related to lack of information or possible misinterpretation of information provided about the procedure

Knowledge deficit related to legal implications of testing

Potential for noncompliance with test protocols related to inability to understand or follow instructions

Potential for noncompliance with test protocols related to presence of high anxiety, confusion, or denial

Potential for noncompliance with test protocols related to lack of knowledge or appropriate instruction

Potential for noncompliance with test protocols related to confusion, weakness, and other individual factors

INTRATEST PHASE

Risk for injury related to developmental age, psychological factors, and test procedures

Risk for infection or allergic reaction related to altered immune function, history of chronic illness, allergens, or infectious agent

Risk for latex allergy response associated with test equipment

Pain, nausea, vomiting, or diarrhea related to laboratory and diagnostic procedures

Injury, actual or risk for, related to invasive procedure associated with laboratory or diagnostic testing

Risk for infection related to invasive procedures

Risk for bleeding associated with altered bleeding tendencies related to invasive procedures

Fatigue related to diagnostic procedure

Anxiety and fear related to arterial puncture or venipuncture

Risk for injury, bleeding, hematoma, or infection related to arterial puncture or venipuncture

Pain related to arterial puncture or venipuncture

Risk for impaired skin integrity

Potential impairment of gas exchange associated with test procedure

POST-TEST PHASE

Knowledge deficit related to significance of test results and potential need for further testing

Knowledge deficit related to test outcome deviation that may necessitate medication or lifestyle alterations

Anxiety and fear related to test outcome that may necessitate medication or lifestyle alterations

Ineffective coping related to test outcome and potential for other interventional techniques or procedures

Anticipatory grieving related to test outcome

Anticipatory or actual grieving related to perceived loss of health or threat of death associated with diagnostic outcome

Decisional conflict related to test outcome and potential for interventional procedures

Potential alteration in tissue perfusion: cerebral, cardiopulmonary, or peripheral

Knowledge deficit related to care after procedure

Guidelines for Age-Specific Communication

Effective communication between the health care provider and the patient is influenced by the patient's cognitive abilities, sensory development or deprivation, level of stress, and environment. Effective communication with individuals at any stage of life is possible if one recognizes that it is essential to employ age-specific communication techniques based on an understanding of the continuum of human development as highlighted here.

INFANT (BIRTH TO 1 YR)

Physical

Rapid gains in height and weight
Gradual shift from reflexive movements to intentional actions

Motor and Sensory

Responds to light and sound
Progresses to raising and turning head, bringing hand to mouth, rolling over, sitting upright, and standing

Cognitive

Learns by imitation
Progresses to recognize familiar objects and people
Advances to speaking three or four words

Psychosocial

Significant persons are parents or primary caregivers
Develops sense of trust and security if needs are met
May show fear of strangers
May exhibit separation anxiety

Interventions

Keep a parent or primary caregiver in view
Involve significant persons in care if appropriate
Provide consistency in health care staff to limit the number of strangers
Face the infant when providing care
Use soothing nonverbal communication, such as holding, rocking, and cuddling
Assess immunizations
Maintain safety and keep crib side rails up at all times

TODDLER (1 TO 4 YR)

Physical

Learning bladder and bowel control
Temporary teeth erupt
Physiological systems mature

Motor and Sensory

Developing a higher level of manual dexterity (builds towers with blocks)
Progresses to walking, jumping, and climbing
Loves to experiment

Cognitive

Has a short attention span
Understands simple directions and requests

Psychosocial

Significant persons are parents
Asserts independence
Understands ownership
Attached to security objects
Knows own gender
Plays simple games

Interventions

Face the toddler during interactions
Give one direction at a time
Tie words to action (toddlers learn by example)
Use firm, direct approach; avoid harsh/excited words or actions
Use distraction techniques
Use soothing nonverbal communication, such as rocking, cuddling, and holding
Communicate through play (dolls, puppets, music)
Prepare shortly before a procedure
Allow choices when possible

Encourage mother or parent to stay with the child as appropriate
Encourage parents to participate in care as appropriate
Maintain safety and keep crib side rails up at all times

CHILD (5 TO 12 YR)

Physical

Growth is slow and regular
Permanent teeth erupt
Pubescent changes start
May experience growing pains
May experience fatigue

Motor and Sensory

Skips and hops
Dresses and undresses independently
Throws and catches a ball
Uses common utensils and tools
Draws, paints, and likes quiet as well as active games

Cognitive

Major cognitive skill is communication
Understands numbers and can count
Constructs sentences and asks questions
Capable of logical thinking and can reason
Takes pride in accomplishments
Develops increased attention span

Psychosocial

Significant persons are parents, siblings, peers, teachers (prefers friends to family)
Increases independence and begins to assert self (may be physically aggressive)
Masters new tasks and acquires new skills
Behavior can be modified by rewards and punishment
Works hard to be successful

Interventions

Clearly define and reinforce behavior limits
Tell jokes and play games with rules
Check for special words used to identify parents, body parts, or body functions
Explain procedures in advance using correct terminology

Use dolls or puppets for explanations when performing procedures
Provide privacy
Involve whenever possible
Allow to have some control
Promote independence
Praise for good behavior
Acknowledge fear, pain, or family separation

ADOLESCENT (13 TO 18 YR)

Physical

Growth in skeletal size is rapid
Reproductive system matures
Vital signs approximate those of an adult

Motor and Sensory

Easily fatigued
May need more rest and sleep in early adolescence
Awkwardness in gross motor activity
Demonstrates improving fine motor skills

Cognitive

Increased ability to use abstract thought and logic
Able to handle hypothetical situations and thoughts
Shows growth in self-esteem but is challenged by bouts of insecurity
Avoids asking questions for fear of appearing unintelligent

Psychosocial

Develops sexual identity
Shows interest in and confusion with own development
Develops concern with physical appearance
Establishes critical need for privacy
Values belonging to peer group
Perceives self as invincible
Identity is threatened by hospitalization

Interventions

Likes to be treated like an adult
Do not talk to others about the patient in front of him or her
Do not ask questions about drugs, sex, or use of tobacco in front of parents
Provide information about routines and therapy

Provide privacy
 Supplement information with rationale
 Encourage questions
 Allow to maintain control
 Involve in decision making and care
 Allow for expression of fear, such as fear
 of bodily injury and loss of control

ADULT (19 TO 65 YEARS)

Physical

Reaches physical and sexual maturity
 Prone to health problems related to an
 inability to cope with new responsibilities
 Health care needs related to preventive
 medicine
 Adjustment to menopause (women) and
 sexual dysfunction (men) in middle
 adulthood

Motor and Sensory

Skills are fully developed

Cognitive

Focuses on time constraints and want to
 learn only what is practical for him or her
 May be dual caregivers (i.e., parents and
 children)

Psychosocial

Experiences emotional stress secondary
 to mate selection, vocational selection,
 assuming occupational roles, marriage,
 childbearing, financial pressure, and
 independence

Interventions

Involve family in patient's care and
 education
 Explain benefits of adhering to treatment
 plan
 Be honest and supportive
 Respect personal values
 Provide privacy
 Keep a hopeful attitude
 Focus on strengths, and not limitations
 Recognize that unknown factors may
 affect behavior
 Encourage patient to ask questions and
 talk about concerns
 Provide information and support to make
 health care decisions

GERIATRIC (65 AND OLDER)

Physical

Ages gradually and individually
 Experiences decreased tolerance to
 heat/cold
 Encounters declining cardiac and renal
 function
 Experiences skeletal changes (bones
 become more prominent, shrinkage in
 vertebral disks, stiff joints)
 Becomes subject to increased
 susceptibility to infection and to high
 blood pressure
 Undergoes skin changes

Motor and Sensory

Experiences decrease in mobility, visual
 acuity, ability to respond to stimuli,
 hearing, and motor skills

Cognitive

Experiences decrease in memory, slowing
 of mental functions, slowness in learning,
 and drop in performance

Psychosocial

Encounters lifestyle changes secondary to
 children leaving home, children providing
 grandchildren, re-establishing a relation-
 ship as a couple, and retirement/hobbies
 Develops increased concern for health and
 financial security
 Accepts concept of own mortality
 Faces decreased authority and autonomy
 Experiences depression related to
 decreased physical, motor, and cognitive
 abilities

Interventions

Explain instructions well to patient and
 family
 Ask questions to verify understanding
 Review important points repeatedly
 Keep room clutter-free and call bell within
 reach
 Control room temperature for comfort
 Consider additional lighting at night
 Watch for signs of drug toxicity
 Give respect and provide privacy
 Focus on strengths, and not limitations
 Avoid assuming loss of abilities

Seek information as necessary to deal with impairments

Include patient in conversation/activity to prevent social isolation

Encourage to talk about feelings

Use humor and stay positive

Provide information and support regarding end-of-life decisions

Provide teaching for safety

Provide teaching for medications and test preparations

Appendix D

Transfusion Reactions: Laboratory Findings and Potential Nursing Interventions

These reactions are mainly associated with the transfusion of leuko-reduced packed red blood cells.

CATEGORIES:

- I. Acute (Less than 24 hr)
Immune-Mediated Transfusion Reactions
 - a. ABO and non-ABO acute hemolytic
 - b. Febrile nonhemolytic
 - c. Urticarial/allergic reaction
 - d. Anaphylactic reaction
- II. Acute (Less than 24 hr)
Non-Immune-Mediated Transfusion Reactions
 - a. Transfusion-related acute lung injury
 - b. Circulatory overload
 - c. Metabolic complications
 - d. Hypothermia
 - e. Hypotension associated with angiotensin-converting enzyme inhibition
 - f. Embolism (air and particulate)
 - g. Nonimmune hemolysis
- III. Delayed (Greater than 24 hr)
Immune-Mediated Transfusion Reactions
 - a. Hemolytic
 - b. Alloimmunization to red blood cell, white blood cell, platelet, and protein antigens
 - c. Graft versus host
- IV. Delayed (Greater than 24 hr)
Non-Immune-Mediated Transfusion Reactions
 - a. Iron overload

APP

I. Acute Immune-Mediated Transfusion Reactions

a. <i>ABO and non-ABO</i> acute hemolytic	Dramatic, severe, and can be fatal; incidence 1:38,000 to 1:70,000 units; result of reaction between antibodies in the patient's plasma and the corresponding antigen being present on the donor's cells; severity affected by amount of patient antibody present, quantity of antigen on transfused cells, volume of blood transfused
Symptoms	Fever, chills, hypotension, tachycardia, nausea, vomiting, lower back pain, hemoglobinuria, renal failure with oliguria, flushing, generalized bleeding, pain or oozing at the infusion site
Lab Findings	Positive DAT; elevated: indirect bilirubin (5 to 7 hr post-transfusion), LDH, BUN, creatinine, PT, aPTT; decreased: anti-A and anti-B titers, haptoglobin; hemoglobinemia; hemoglobinuria; hypofibrinogenemia; thrombocytopenia; positive urinary hemosiderin; presence of spherocytes and RBC fragments on peripheral smear

(table continues on page 1270)

I. Acute Immune-Mediated Transfusion Reactions (continued)

Treatment	Immediately stop transfusion, maintain renal flow at greater than 100 mL/hr by use of osmotic and diuretic agents (e.g., lasix, furosemide); monitor for development of DIC (uncontrolled bleeding, decreasing platelet count, prolonged PT/PTT); future transfusion with O-negative packed cells
<i>b. Febrile nonhemolytic</i>	Most common type of transfusion reaction; incidence 1:200 to 1:17 (0.5% to 6.0%); repeat occurrences are uncommon; result of antileukocyte, antiplatelet, or anti-HLA antibodies
Symptoms	Fever, chills, headache, vomiting
Lab Findings	Negative DAT; transient leukopenia
Treatment	Immediately stop transfusion; administer antipyretics (steroids in severe cases); transfuse with leukocyte-reduced blood after two documented febrile nonhemolytic reactions
<i>c. Urticarial/allergic reaction</i>	Second most common type of reaction; incidence 1:100 to 1:33 (1% to 3%); histamine-mediated reaction of allergin + IgE fixed on mast cells
Symptoms	Local erythema; hives; itching; usually no fever
Lab Findings	Negative DAT
Treatment	Immediately stop transfusion; keep line open; administer antihistamines (e.g., diphenhydramine 25 to 50 mg); resume transfusion when symptoms subside; for future transfusions, premedicate with antihistamines
<i>d. Anaphylactic reaction</i>	Occurs rapidly with 10 mL or less; 1 in 700 individuals are IgA deficient and 25% have anti-IgA antibodies that will react to donor's plasma proteins; incidence 1:20,000 to 1:50,000
Symptoms	Hypotension, urticaria, flushing, substernal pain, abdominal cramping, laryngeal edema, bronchospasm, circulatory collapse, anxiety
Lab Findings	Negative DAT; presence of IgG class anti-IgA antibodies or undetectable level of IgA
Treatment	Treat for anaphylaxis with epinephrine, steroid therapy as needed, oxygen therapy as needed, Trendelenburg position, fluids; for future transfusions, premedicate with antihistamines and transfuse with IgA-deficient donor blood or autologous blood

II. Acute Non-Immune-Mediated Transfusion Reactions

<i>a. Transfusion-related acute lung injury</i>	Incidence of reaction to anti-WBC antibodies in donated whole blood-derived platelets, 1:432; and plasma-containing blood component, 1:2000;
---	--

(table continues on page 1271)

	blood blood component, 1:5000; fresh frozen plasma, 1:7900
Symptoms	Hypoxemia, respiratory failure, hypotension, fever
Lab Findings	Positive WBC antibody screen (donor or recipient), incompatible WBC crossmatch
Treatment	Supportive care until recovered; implicated donors should be deferred from future donation
<i>b. Circulatory overload</i>	Incidence less than 1%; result of volume overload
Symptoms	Dyspnea, orthopnea, cough, tachycardia, hypertension, headache
Lab Findings	N/A
Treatment	Upright posture; oxygen; diuretic; administer blood slowly; phlebotomy (250-mL increments)
<i>c. Metabolic complications</i>	Hypocalcemia resulting from rapid massive infusion of citrate; incidence dependent on clinical setting
Symptoms	Paresthesia, tetany, arrhythmia
Lab Findings	Elevated ionized calcium level, prolonged Q-T interval on EKG
Treatment	Slow calcium infusion, oral calcium supplement for mild symptoms; monitor ionized calcium levels (severe symptoms)
<i>d. Hypothermia</i>	Result of rapid infusion of cold blood
Symptoms	Cardiac arrhythmia
Lab Findings	N/A
Treatment	Utilize blood warmer
<i>e. Hypotension associated with ACE inhibition</i>	Patients on ACE inhibitors receiving leukocyte-reduced packed cells have experienced hypotension (believed to be the result of an interaction between the ACE inhibitor and the kinin/ prekallikrein system); incidence is dependent on the clinical setting.
Symptoms	Flushing, hypotension
Lab Findings	Positive DAT, hemolyzed intra- or post-transfusion specimen
Treatment	Avoid bedside leukocyte filtration
<i>f. Embolism (air and particulate)</i>	Result of air infusion via line; incidence is rare
Symptoms	Sudden shortness of breath; acute cyanosis; pain; cough; hypotension; cardiac arrhythmia
Lab Findings	N/A
Treatment	Position patient on left side with legs elevated above head and chest
<i>g. Nonimmune hemolysis</i>	Result of physical or chemical destruction of RBCs (e.g., heating, freezing, hemolytic drug, solution added to blood); incidence is rare
Symptoms	Hemoglobinuria
Lab Findings	Positive plasma-free hemoglobin, positive DAT, obvious hemolysis in unit containing the blood
Treatment	Identify and eliminate cause

(table continues on page 1272)

III. Delayed Immune-Mediated Transfusion Reactions

<i>a. Hemolytic</i>	Anamnestic immune response to RBC antigens; incidence 1:11,000 to 1:50,000
Symptoms	Fever, anemia, mild jaundice
Lab Findings	Positive antibody screen, urinary hemosiderin and DAT; increased LDH, bilirubin
Treatment	Identify antibody and transfuse compatible blood as needed
<i>b. Alloimmunization to RBC, WBC, platelet, and protein antigens</i>	Immune response to RBC, WBC, or platelet antigens; incidence 1:100
Symptoms	Delayed hemolytic reaction
Lab Findings	Positive antibody screen and DAT
Treatment	Avoid unnecessary transfusions; give leukocyte-reduced blood if transfusion is necessary
<i>c. Graft versus host</i>	Donor lymphocytes attack recipient's host tissue; incidence is rare
Symptoms	Erythroderma, maculopapular rash, anorexia, nausea, vomiting, diarrhea, hepatitis, pancytopenia, fever
Lab Findings	Abnormal skin biopsy, incompatible HLA typing
Treatment	Methotrexate, corticosteroids; transfuse with irradiated blood products

IV. Delayed Non-Immune-Mediated Transfusion Reactions

<i>a. Iron overload</i>	Result of chronic transfusions (greater than 100)
Symptoms	Symptoms associated with diabetes, cirrhosis, cardiomyopathy
Lab Findings	Increased iron levels
Treatment	Desferioxamine

ACE = angiotensin-converting enzyme; BUN = blood urea nitrogen; DAT = (Coombs') direct antiglobulin test; DIC = disseminated intravascular coagulation; ECG = electrocardiogram; HLA = human leukocyte antigen; Ig = immunoglobulin; LDH = lactate dehydrogenase; N/A = not applicable; PT = prothrombin time; PTT = partial thromboplastin time; RBC = red blood cell; WBC = white blood cell.

Introduction to CLIA 1988 & 1992

The acronym *CLIA* stands for Clinical Laboratory Improvement Amendments. In 1988, Congress passed CLIA in order to establish quality standards that would apply to laboratory testing nationwide. The standards ensure that, regardless of location, all clinical testing on human specimens is performed with accuracy, reliability, and timeliness. In 1992, CLIA's final regulations distinguished between levels of test complexity. Three categories were established: waived complexity, moderate complexity (includes the subcategory of Provider-Performed Microscopy [PPM]), and high complexity testing. Permission to perform clinical laboratory testing in any or all categories requires the laboratory director to submit an application to enroll in the CLIA program, pay the applicable fee, and meet quality requirements that correspond to the type of certificate that is obtained. The 10–1–04 edition of 42 CFR Ch. IV, the most current revision of CLIA, is the source used to write this introduction.

A Certificate of Waiver (COW) obtained by the appropriate health care provider (HCP) allows qualified nursing or other health care personnel to perform procedures classified as waived testing in a HCP's office or in a hospital nursing unit. Waived testing includes tests that are cleared by the Food and Drug Administration (FDA) for home use, have manufacturers' instructions to follow, and pose no harm to the patient if testing is performed incorrectly. The testing process utilizes controls. Examples of waived testing include dipstick urinalysis, fecal occult blood, ovulation testing, urine pregnancy tests, erythrocyte sedimentation rate (nonautomated), hemoglobin (copper sulfate method), blood glucose (on glucose meters cleared by the FDA), spun hematocrit, and hemoglobin by single analyte instruments that are self contained with direct measurement and readout.

PPM laboratories perform moderately complex testing. This type of testing can be performed in a HCP's office. A PPM certificate obtained by a physician or midlevel practitioner allows the practitioner to perform moderately complex testing on specimens obtained during the patient's office visit, in addition to waived testing. A midlevel practitioner can perform this type of testing under the direct supervision of a physician or in independent practice if authorized by the State. A microscope is utilized to view the specimens during the patient's office visit. These moderately complex tests are performed on specimens in situations in which the accuracy of the findings would be compromised if a delay in testing were to occur. The testing process has no available controls. Examples of PPM testing include urine sediment examinations, potassium hydroxide preparations, pinworm examinations, fern tests, nasal smears for granulocytes, fecal leukocyte examinations, qualitative semen analysis (limited to determining the presence or absence of sperm and detection of motility), post coital direct, qualitative examinations of vaginal or cervical mucus, and wet mount testing for the presence or absence of bacteria, fungi, parasites, and cellular elements.

Hospital and reference laboratories perform tests of high complexity. The laboratory director must obtain the corresponding CLIA certificate and have personnel qualified to perform tests of high complexity.

Effects of Natural Products on Laboratory Values

The use of natural products has increased significantly, but to date, their preparation is unregulated. Their actions can affect normal and abnormal physiologic processes as well as interact with prescription medications. Their presence in the body, alone or in combination with over-the-counter products or prescription medications, may physiologically affect the intended target or cause analytical interference in such a way that the test result is affected. For this reason, it is important to note their use. The natural products listed here are contraindicated or are recommended for use with caution in patients with body system disorders or patients taking medications for these disorders. The requesting health care provider (HCP) and laboratory should be advised if the patient is regularly using these products so that their potential effects can be taken into consideration when reviewing results.

This list is not all-inclusive. Questions regarding the potential benefits and contraindications of natural products should be referred to the appropriate HCP. As a general recommendation, natural products and nutraceuticals are contraindicated during pregnancy and lactation.

NATURAL PRODUCTS THAT MAY AFFECT CARDIOVASCULAR DISORDERS OR INTERACT WITH THERAPEUTICS (INCLUDING HYPERTENSION AND HYPOTENSION)

Adonis
Aloe
Bromelain
Buckthorn
Cascara
Chinese rhubarb
Coleus
Dong quai
Elder
Ephedra
Ergot
Frangula
Garlic
Ginseng
Goldenseal
Green tea (with caffeine)
Henbane
Horsetail
Lily of the valley
Ma-huang
Reishi
Senna
Squill
Tylophora
Valerian
Yohimbe bark

NATURAL PRODUCTS AND NUTRACEUTICALS THAT MAY AFFECT ENDOCRINE DISORDERS OR INTERACT WITH THERAPEUTICS

Natural Products

Bilberry
Bitter melon
Bladderwrack
Blupleurum
Bugleweed
Echinacea
Ephedra
Fenugreek
Garcinia
Garlic
Ginseng
Goat's rue
Green tea (with caffeine)
Guggul
Licorice
Marshmallow
Olive leaf
Psyllium
Tylophora

Minerals

Chromium
Nutraceuticals
Dehydroepiandrosterone
a-Lipoic acid

Para-aminobenzoic acid
Thyroid extract

NATURAL PRODUCTS AND NUTRACEUTICALS THAT MAY AFFECT GASTROINTESTINAL DISORDERS OR INTERACT WITH THERAPEUTICS

Natural Products

Bromelain
Cascara
Chinese rhubarb
Dandelion
Psyllium
Senna
Nutraceuticals
Betaine hydrochloride

NATURAL PRODUCTS AND NUTRACEUTICALS THAT MAY AFFECT GENITOURINARY DISORDERS OR INTERACT WITH THERAPEUTICS

Natural Products

Aloe
Arabinosylane
Bladderwrack
Buckthorn
Cascara
Chinese rhubarb
Dandelion
Echinacea
Ephedra
Ergot
Frangula
Ginseng
Guarana
Horse chestnut
Horsetail
Licorice
Parsley oil (high doses)
Saw palmetto
Senna
Stinging nettle
White oak
White willow

Nutraceuticals

Creatine
Modified citrus pectin

NATURAL PRODUCTS AND NUTRACEUTICALS THAT MAY AFFECT BLEEDING DISORDERS OR INTERACT WITH THERAPEUTICS

Natural Products

Arnica
Astragalus
Bilberry
Bromelian
Cat's claw
Cayenne
Coleus
Cordyceps
Devil's claw
Dong quai
Evening primrose
Feverfew
Garlic
Ginger
Ginkgo
Ginseng
Grape seed
Green tea (with caffeine)
Guggui
Horse chestnut
Papaya
Red clover
Red yeast rice
Reishi
Turmeric
White willow

Nutraceuticals

Docosahexaenoic acid (DHA)
Fish oils (the omega-3 fatty acids: EPA and DHA)

NATURAL PRODUCTS AND NUTRACEUTICALS THAT MAY AFFECT HEPATOBILIARY DISORDERS OR INTERACT WITH THERAPEUTICS

Natural Products

Alkanet
Alpine ragwort
Coltsfoot
Comfrey
Dusty miller
Forget-me-not

Germander
Groundsel
Olive leaf
Parsley oil (large doses)
Pennyroyal
Peppermint
Ragwort
Red yeast rice
Sweet clover
White oak
White willow

Nutraceuticals

Creatine

NATURAL PRODUCTS AND AMINO ACIDS THAT MAY AFFECT IMMUNE DISORDERS OR INTERACT WITH THERAPEUTICS

Natural Products

Astragalus
Black cohosh

Echinacea
Saw palmetto

Amino Acids

Arginine

NATURAL PRODUCTS THAT MAY AFFECT RESPIRATORY DISORDERS OR INTERACT WITH THERAPEUTICS

Artichoke
Cayenne
Chamomile
Cordyceps
Echinacea
Feverfew
Garlic
Peppermint oil
White willow

Standard and Universal Precautions

Recommendations for Isolation Precautions in Hospitals

RATIONALE FOR ISOLATION PRECAUTIONS IN HOSPITALS

Transmission of infection within a hospital requires three elements: a source of infecting microorganisms, a susceptible host, and a means of transmission for the microorganism.

Source

Human sources of the infecting microorganisms in hospitals may be patients, personnel, or, on occasion, visitors, and may include persons with acute disease, persons in the incubation period of a disease, persons who are colonized by an infectious agent but have no apparent disease, or persons who are chronic carriers of an infectious agent. Other sources of infecting microorganisms can be the patient's own endogenous flora, which may be difficult to control, and inanimate environmental objects that have become contaminated, including equipment and medications.

Host

Resistance among persons to pathogenic microorganisms varies greatly. Some persons may be immune to infection or may be able to resist colonization by an infectious agent; others exposed to the same agent may establish a commensal relationship with the infecting microorganism and become asymptomatic carriers; still others may develop clinical disease. Host factors such as age; underlying diseases; certain treatments with antimicrobials, corticosteroids, or other immunosuppressive agents; irradiation; and breaks in the first line of defense mechanisms caused by such factors as surgical operations, anesthesia, and indwelling catheters may render patients more susceptible to infection.

Transmission

Microorganisms are transmitted in hospitals by several routes, and the same microorganism may be transmitted by more than one route. There are five main routes of transmission: contact, droplet, airborne, common vehicle, and vectorborne. For the purpose of this guideline, common vehicle and vectorborne transmission will be discussed only briefly, because neither play a significant role in typical nosocomial infections.

1. *Contact transmission*, the most important and frequent mode of transmission of nosocomial infections, is divided into two subgroups: direct-contact transmission and indirect-contact transmission.
2. Direct-contact transmission involves a direct body surface-to-body surface contact and physical transfer of microorganisms between a susceptible host and an infected or colonized person, such as occurs when a person turns a patient, gives a patient a bath, or performs other patient-care activities that require direct personal contact. Direct-contact transmission also can occur between two patients, with one serving as the source of the infectious microorganisms and the other as a susceptible host.
3. Indirect-contact transmission involves contact of a susceptible host with a contaminated intermediate object, usually inanimate, such as contaminated

instruments, needles, or dressings, or contaminated hands that are not washed and gloves that are not changed between patients.

4. *Droplet transmission*, theoretically, is a form of contact transmission. However, the mechanism of transfer of the pathogen to the host is quite distinct from either direct- or indirect-contact transmission. Therefore, droplet transmission will be considered a separate route of transmission in this guideline. Droplets are generated from the source person primarily during coughing, sneezing, and talking, and during the performance of certain procedures such as suctioning and bronchoscopy. Transmission occurs when droplets containing microorganisms generated from the infected person are propelled a short distance through the air and deposited on the host's conjunctivae, nasal mucosa, or mouth. Because droplets do not remain suspended in the air, special air handling and ventilation are not required to prevent droplet transmission; that is, droplet transmission *must not* be confused with airborne transmission.
5. *Airborne transmission* occurs by dissemination of either airborne droplet nuclei (small-particle residue [5 μm or smaller in size] of evaporated droplets containing microorganisms that remain suspended in the air for long periods of time) or dust particles containing the infectious agent. Microorganisms carried in this manner can be dispersed widely by air currents and may become inhaled by a susceptible host within the same room or over a longer distance from the source patient, depending on environmental factors; therefore, special air handling and ventilation are required to prevent airborne transmission. Microorganisms transmitted by airborne transmission include *Mycobacterium tuberculosis* and the rubeola and varicella viruses.
6. *Common vehicle transmission* applies to microorganisms transmitted by contaminated items such as food, water, medications, devices, and equipment.
7. *Vectorborne transmission* occurs when vectors such as mosquitoes, flies, rats, and other vermin transmit microorganisms; this route of transmission is of less significance in hospitals in the United States than in other regions of the world.

Isolation precautions are designed to prevent transmission of microorganisms by these routes in hospitals. Because agent and host factors are more difficult to control, interruption of transfer of microorganisms is directed primarily at transmission. The recommendations presented in this guideline are based on this concept.

Placing a patient on isolation precautions, however, often presents certain disadvantages to the hospital, patients, personnel, and visitors. Isolation precautions may require specialized equipment and environmental modifications that add to the cost of hospitalization. Isolation precautions may make frequent visits by nurses, physicians, and other personnel inconvenient, and they may make it more difficult for personnel to give the prompt and frequent care that sometimes is required. The use of a multi-patient room for one patient uses valuable space that otherwise might accommodate several patients. Moreover, forced solitude deprives the patient of normal social relationships and may be psychologically harmful, especially to children. These disadvantages, however, must be weighed against the hospital's mission to prevent the spread of serious and epidemiologically important microorganisms in the hospital.

FUNDAMENTALS OF ISOLATION PRECAUTIONS

A variety of infection control measures are used for decreasing the risk of transmission of microorganisms in hospitals. These measures make up the fundamentals of isolation precautions.

Handwashing and Gloving

Handwashing frequently is called the single most important measure to reduce the risks of transmitting organisms from one person to another or from one site to another on the same patient. The scientific rationale, indications, methods, and products for handwashing are delineated in other publications.

Washing hands as promptly and thoroughly as possible between patient contacts and after contact with blood, body fluids, secretions, excretions, and equipment or articles contaminated by them is an important component of infection control and isolation precautions. In addition to handwashing, gloves play an important role in reducing the risks of transmission of microorganisms.

Gloves are worn for three important reasons in hospitals. First, gloves are worn to provide a protective barrier and to prevent gross contamination of the hands when touching blood, body fluids, secretions, excretions, mucous membranes, and nonintact skin; the wearing of gloves in specified circumstances to reduce the risk of exposures to bloodborne pathogens is mandated by the OSHA bloodborne pathogens final rule. Second, gloves are worn to reduce the likelihood that microorganisms present on the hands of personnel will be transmitted to patients during invasive or other patient-care procedures that involve touching a patient's mucous membranes and nonintact skin. Third, gloves are worn to reduce the likelihood that hands of personnel contaminated with microorganisms from a patient or a fomite can transmit these microorganisms to another patient. In this situation, gloves must be changed between patient contacts and hands washed after gloves are removed.

Wearing gloves does not replace the need for handwashing, because gloves may have small, inapparent defects or may be torn during use, and hands can become contaminated during removal of gloves. Failure to change gloves between patient contacts is an infection control hazard.

Patient Placement

Appropriate patient placement is a significant component of isolation precautions. A private room is important to prevent direct- or indirect-contact transmission when the source patient has poor hygienic habits, contaminates the environment, or cannot be expected to assist in maintaining infection control precautions to limit transmission of microorganisms (e.g., infants, children, and patients with altered mental status). When possible, a patient with highly transmissible or epidemiologically important microorganisms is placed in a private room with handwashing and toilet facilities to reduce opportunities for transmission of microorganisms.

When a private room is not available, an infected patient is placed with an appropriate roommate. Patients infected by the same microorganism usually can share a room, provided they are not infected with other potentially transmissible microorganisms and the likelihood of reinfection with the same organism is minimal. Such sharing of rooms, also referred to as cohorting patients, is useful especially during outbreaks or when there is a shortage of private rooms. When a private room is not available and cohorting is not achievable or recommended, it is very important to consider the epidemiology and mode of transmission of the infecting pathogen and the patient population being served

in determining patient placement. Under these circumstances, consultation with infection control professionals is advised before patient placement. Moreover, when an infected patient shares a room with a noninfected patient, it also is important that patients, personnel, and visitors take precautions to prevent the spread of infection and that roommates are selected carefully.

Guidelines for construction, equipment, air handling, and ventilation for isolation rooms are delineated in other publications. A private room with appropriate air handling and ventilation is particularly important for reducing the risk of transmission of microorganisms from a source patient to susceptible patients and other persons in hospitals when the microorganism is spread by airborne transmission. Some hospitals use an isolation room with an anteroom as an extra measure of precaution to prevent airborne transmission. Adequate data regarding the need for an anteroom, however, is not available. Ventilation recommendations for isolation rooms housing patients with pulmonary tuberculosis have been delineated in other CDC guidelines.

Transport of Infected Patients

Limiting the movement and transport of patients infected with virulent or epidemiologically important microorganisms and ensuring that such patients leave their rooms only for essential purposes reduces opportunities for transmission of microorganisms in hospitals. When patient transport is necessary, it is important that 1) appropriate barriers (e.g., masks, impervious dressings) are worn or used by the patient to reduce the opportunity for transmission of pertinent microorganisms to other patients, personnel, and visitors and to reduce contamination of the environment; 2) personnel in the area to which the patient is to be taken are notified of the impending arrival of the patient and of the precautions to be used to reduce the risk of transmission of infectious microorganisms; and 3) patients are informed of ways by which they can assist in preventing the transmission of their infectious microorganisms to others.

Masks, Respiratory Protection, Eye Protection, Face Shields

Various types of masks, goggles, and face shields are worn alone or in combination to provide barrier protection. A mask that covers both the nose and the mouth, and goggles or a face shield are worn by hospital personnel during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions to provide protection of the mucous membranes of the eyes, nose, and mouth from contact transmission of pathogens. The wearing of masks, eye protection, and face shields in specified circumstances to reduce the risk of exposures to bloodborne pathogens is mandated by the OSHA bloodborne pathogens final rule. A surgical mask generally is worn by hospital personnel to provide protection against spread of infectious large-particle droplets that are transmitted by close contact and generally travel only short distances (up to 3 ft) from infected patients who are coughing or sneezing.

An area of major concern and controversy over the last several years has been the role and selection of respiratory protection equipment and the implications of a respiratory protection program for prevention of transmission of tuberculosis in hospitals. Traditionally, although the efficacy was not proven, a surgical mask was worn for isolation precautions in hospitals when patients were known or suspected to be infected with pathogens spread by the airborne route of transmission. In 1990, however, the CDC tuberculosis

guidelines stated that surgical masks may not be effective in preventing the inhalation of droplet nuclei and recommended the use of disposable particulate respirators, despite the fact that the efficacy of particulate respirators in protecting persons from the inhalation of *M. tuberculosis* had not been demonstrated. By definition, particulate respirators included dust-mist (DM), dust-fume-mist (DFM), or high-efficiency particulate air (HEPA) filter respirators certified by the CDC National Institute for Occupational Safety and Health (NIOSH); because the generic term “particulate respirator” was used in the 1990 guidelines, the implication was that any of these respirators provided sufficient protection.

In 1993, a draft revision of the CDC tuberculosis guidelines outlined performance criteria for respirators and stated that some DM or DFM respirators might not meet these criteria. After review of public comments, the guidelines were finalized in October 1994, with the draft respirator criteria unchanged. At that time, the only class of respirators that were known to consistently meet or exceed the performance criteria outlined in the 1994 tuberculosis guidelines and that were certified by NIOSH (as required by OSHA) were HEPA filter respirators. Subsequently, NIOSH revised the testing and certification requirements for all types of air-purifying respirators, including those used for tuberculosis control. The new rule, effective in July 1995, provides a broader range of certified respirators that meet the performance criteria recommended by CDC in the 1994 tuberculosis guidelines. NIOSH has indicated that the N95 (N category at 95% efficiency) meets the CDC performance criteria for a tuberculosis respirator. The new respirators are likely to be available in late 1995. Additional information on the evolution of respirator recommendations, regulations to protect hospital personnel, and the role of various federal agencies in respiratory protection for hospital personnel has been published.

Gowns and Protective Apparel

Various types of gowns and protective apparel are worn to provide barrier protection and to reduce opportunities for transmission of microorganisms in hospitals. Gowns are worn to prevent contamination of clothing and to protect the skin of personnel from blood and body fluid exposures. Gowns especially treated to make them impermeable to liquids, leg coverings, boots, or shoe covers provide greater protection to the skin when splashes or large quantities of infective material are present or anticipated. The wearing of gowns and protective apparel under specified circumstances to reduce the risk of exposures to bloodborne pathogens is mandated by the OSHA bloodborne pathogens final rule.

Gowns are also worn by personnel during the care of patients infected with epidemiologically important microorganisms to reduce the opportunity for transmission of pathogens from patients or items in their environment to other patients or environments; when gowns are worn for this purpose, they are removed before leaving the patient’s environment and hands are washed. Adequate data regarding the efficacy of gowns for this purpose, however, are not available.

Patient-Care Equipment and Articles

Many factors determine whether special handling and disposal of used patient-care equipment and articles are prudent or required, including the likelihood of contamination with infective material; the ability to cut, stick, or

otherwise cause injury (needles, scalpels, and other sharp instruments [sharps]); the severity of the associated disease; and the environmental stability of the pathogens involved. Some used articles are enclosed in containers or bags to prevent inadvertent exposures to patients, personnel, and visitors and to prevent contamination of the environment. Used sharps are placed in puncture-resistant containers; other articles are placed in a bag. One bag is adequate if the bag is sturdy and the article can be placed in the bag without contaminating the outside of the bag; otherwise, two bags are used.

The scientific rationale, indications, methods, products, and equipment for reprocessing patient-care equipment are delineated in other publications. Contaminated, reusable critical medical devices or patient-care equipment (i.e., equipment that enters normally sterile tissue or through which blood flows) or semicritical medical devices or patient-care equipment (i.e., equipment that touches mucous membranes) are sterilized or disinfected (reprocessed) after use to reduce the risk of transmission of microorganisms to other patients; the type of reprocessing is determined by the article and its intended use, the manufacturer's recommendations, hospital policy, and any applicable guidelines and regulations.

Noncritical equipment (i.e., equipment that touches intact skin) contaminated with blood, body fluids, secretions, or excretions is cleaned and disinfected after use, according to hospital policy. Contaminated disposable (single-use) patient-care equipment is handled and transported in a manner that reduces the risk of transmission of microorganisms and decreases environmental contamination in the hospital; the equipment is disposed of according to hospital policy and applicable regulations.

Linen and Laundry

Although soiled linen may be contaminated with pathogenic microorganisms, the risk of disease transmission is negligible if it is handled, transported, and laundered in a manner that avoids transfer of microorganisms to patients, personnel, and environments. Rather than rigid rules and regulations, hygienic and common sense storage and processing of clean and soiled linen are recommended. The methods for handling, transporting, and laundering of soiled linen are determined by hospital policy and any applicable regulations.

Dishes, Glasses, Cups, and Eating Utensils

No special precautions are needed for dishes, glasses, cups, or eating utensils. Either disposable or reusable dishes and utensils can be used for patients on isolation precautions. The combination of hot water and detergents used in hospital dishwashers is sufficient to decontaminate dishes, glasses, cups, and eating utensils.

Routine and Terminal Cleaning

The room, or cubicle, and bedside equipment of patients on Transmission-Based Precautions are cleaned using the same procedures used for patients on Standard Precautions, unless the infecting microorganism(s) and the amount of environmental contamination indicates special cleaning. In addition to thorough cleaning, adequate disinfection of bedside equipment and environmental surfaces (e.g., bedrails, bedside tables, carts, commodes, doorknobs, faucet handles) is indicated for certain pathogens, especially enterococci, which can survive in the inanimate environment for prolonged periods of time. Patients admitted to hospital rooms that previously were occupied by patients infected

or colonized with such pathogens are at increased risk of infection from contaminated environmental surfaces and bedside equipment if they have not been cleaned and disinfected adequately. The methods, thoroughness, and frequency of cleaning and the products used are determined by hospital policy.

HICPAC ISOLATION PRECAUTIONS

There are two tiers of HICPAC isolation precautions. In the first, and most important, tier are those precautions designed for the care of all patients in hospitals, regardless of their diagnosis or presumed infection status. Implementation of these “Standard Precautions” is the primary strategy for successful nosocomial infection control. In the second tier are precautions designed only for the care of specified patients. These additional “Transmission-Based Precautions” are for patients known or suspected to be infected by epidemiologically important pathogens spread by airborne or droplet transmission or by contact with dry skin or contaminated surfaces.

Standard Precautions

Standard Precautions synthesize the major features of UP (Blood and Body Fluid Precautions) (designed to reduce the risk of transmission of bloodborne pathogens) and BSI (designed to reduce the risk of transmission of pathogens from moist body substances) and applies them to all patients receiving care in hospitals, regardless of their diagnosis or presumed infection status. Standard Precautions apply to 1) blood; 2) all body fluids, secretions, and excretions except sweat, regardless of whether or not they contain visible blood; 3) nonintact skin; and 4) mucous membranes. Standard Precautions are designed to reduce the risk of transmission of microorganisms from both recognized and unrecognized sources of infection in hospitals.

Transmission-Based Precautions

Transmission-Based Precautions are designed for patients documented or suspected to be infected with highly transmissible or epidemiologically important pathogens for which additional precautions beyond Standard Precautions are needed to interrupt transmission in hospitals. There are three types of Transmission-Based Precautions: Airborne Precautions, Droplet Precautions, and Contact Precautions. They may be combined for diseases that have multiple routes of transmission. When used either singularly or in combination, they are to be used in addition to Standard Precautions.

Airborne Precautions are designed to reduce the risk of airborne transmission of infectious agents. Airborne transmission occurs by dissemination of either airborne droplet nuclei (small-particle residue [5 μm or smaller in size] of evaporated droplets that may remain suspended in the air for long periods of time) or dust particles containing the infectious agent. Microorganisms carried in this manner can be dispersed widely by air currents and may become inhaled by or deposited on a susceptible host within the same room or over a longer distance from the source patient, depending on environmental factors; therefore, special air handling and ventilation are required to prevent airborne transmission. Airborne Precautions apply to patients known or suspected to be infected with epidemiologically important pathogens that can be transmitted by the airborne route.

Droplet Precautions are designed to reduce the risk of droplet transmission of infectious agents. Droplet transmission involves contact of the conjunctivae or the mucous membranes of the nose or mouth of a susceptible

person with large-particle droplets (larger than 5 μm in size) containing microorganisms generated from a person who has a clinical disease or who is a carrier of the microorganism. Droplets are generated from the source person primarily during coughing, sneezing, or talking and during the performance of certain procedures such as suctioning and bronchoscopy. Transmission via large-particle droplets requires close contact between source and recipient persons, because droplets do not remain suspended in the air and generally travel only short distances, usually 3 ft or less, through the air. Because droplets do not remain suspended in the air, special air handling and ventilation are not required to prevent droplet transmission. Droplet Precautions apply to any patient known or suspected to be infected with epidemiologically important pathogens that can be transmitted by infectious droplets.

Contact Precautions are designed to reduce the risk of transmission of epidemiologically important microorganisms by direct or indirect contact. Direct-contact transmission involves skin-to-skin contact and physical transfer of microorganisms to a susceptible host from an infected or colonized person, such as occurs when personnel turn patients, bathe patients, or perform other patient-care activities that require physical contact. Direct-contact transmission also can occur between two patients (e.g., by hand contact), with one serving as the source of infectious microorganisms and the other as a susceptible host. Indirect-contact transmission involves contact of a susceptible host with a contaminated intermediate object, usually inanimate, in the patient's environment. Contact Precautions apply to specified patients known or suspected to be infected or colonized (presence of microorganism in or on patient but without clinical signs and symptoms of infection) with epidemiologically important microorganisms than can be transmitted by direct or indirect contact.

EMPIRIC USE OF AIRBORNE, DROPLET, OR CONTACT PRECAUTIONS

In many instances, the risk of nosocomial transmission of infection may be highest before a definitive diagnosis can be made and before precautions based on that diagnosis can be implemented. The routine use of Standard Precautions for all patients should reduce greatly this risk for conditions other than those requiring Airborne, Droplet, or Contact Precautions. While it is not possible to prospectively identify all patients needing these enhanced precautions, certain clinical syndromes and conditions carry a sufficiently high risk to warrant the empiric addition of enhanced precautions while a more definitive diagnosis is pursued.

The organisms listed under the column “Potential Pathogens” are not intended to represent the complete or even most likely diagnoses, but rather possible etiologic agents that require additional precautions beyond Standard Precautions until they can be ruled out. Infection control professionals are encouraged to modify or adapt this table according to local conditions. To ensure that appropriate empiric precautions are implemented always, hospitals must have systems in place to evaluate patients routinely, according to these criteria as part of their preadmission and admission care.

IMMUNOCOMPROMISED PATIENTS

Immunocompromised patients vary in their susceptibility to nosocomial infections, depending on the severity and duration of immunosuppression. They generally are at increased risk for bacterial, fungal, parasitic, and viral infections from both endogenous and exogenous sources. The use of Standard Precautions for all patients and Transmission-Based Precautions for specified

patients, as recommended in this guideline, should reduce the acquisition by these patients of institutionally acquired bacteria from other patients and environments.

It is beyond the scope of this guideline to address the various measures that may be used for immunocompromised patients to delay or prevent acquisition of potential pathogens during temporary periods of neutropenia. Rather, the primary objective of this guideline is to prevent transmission of pathogens from infected or colonized patients in hospitals. Users of this guideline, however, are referred to the “Guideline for Prevention of Nosocomial Pneumonia” (95,96) for the HICPAC recommendations for prevention of nosocomial aspergillosis and Legionnaires’ disease in immunocompromised patients.

RECOMMENDATIONS

The recommendations presented below are categorized as follows:

Category IA. Strongly recommended for all hospitals and strongly supported by well-designed experimental or epidemiologic studies.

Category IB. Strongly recommended for all hospitals and reviewed as effective by experts in the field and a consensus of HICPAC based on strong rationale and suggestive evidence, even though definitive scientific studies have not been done.

Category II. Suggested for implementation in many hospitals. Recommendations may be supported by suggestive clinical or epidemiologic studies, a strong theoretical rationale, or definitive studies applicable to some, but not all, hospitals.

No recommendation; unresolved issue. Practices for which insufficient evidence or consensus regarding efficacy exists.

The recommendations are limited to the topic of isolation precautions. Therefore, they must be supplemented by hospital policies and procedures for other aspects of infection and environmental control, occupational health, administrative and legal issues, and other issues beyond the scope of this guideline.

1. Administrative Controls

- a. Education
Develop a system to ensure that hospital patients, personnel, and visitors are educated about use of precautions and their responsibility for adherence to them. Category IB
- b. Adherence to Precautions
Periodically evaluate adherence to precautions, and use findings to direct improvements. Category IB

2. Standard Precautions

Use Standard Precautions, or the equivalent, for the care of all patients. Category IB

- a. Handwashing
 - (1) Wash hands after touching blood, body fluids, secretions, excretions, and contaminated items, whether or not gloves are worn. Wash hands immediately after gloves are removed, between patient contacts, and when otherwise indicated to avoid transfer of microorganisms to other patients or environments. It may be necessary to wash hands between tasks and procedures on the same patient to prevent cross-contamination of different body sites. Category IB

- (2) Use a plain (nonantimicrobial) soap for routine handwashing.
Category IB
 - (3) Use an antimicrobial agent or a waterless antiseptic agent for specific circumstances (e.g., control of outbreaks or hyperendemic infections), as defined by the infection control program. Category IB
(See Contact Precautions for additional recommendations on using antimicrobial and antiseptic agents.)
- b. Gloves
Wear gloves (clean, nonsterile gloves are adequate) when touching blood, body fluids, secretions, excretions, and contaminated items. Put on clean gloves just before touching mucous membranes and nonintact skin. Change gloves between tasks and procedures on the same patient after contact with material that may contain a high concentration of microorganisms. Remove gloves promptly after use, before touching noncontaminated items and environmental surfaces, and before going to another patient, and wash hands immediately to avoid transfer of microorganisms to other patients or environments. Category IB
 - c. Mask, Eye Protection, Face Shield
Wear a mask and eye protection or a face shield to protect mucous membranes of the eyes, nose, and mouth during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions. Category IB
 - d. Gown
Wear a gown (a clean, nonsterile gown is adequate) to protect skin and to prevent soiling of clothing during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions. Select a gown that is appropriate for the activity and amount of fluid likely to be encountered. Remove a soiled gown as promptly as possible, and wash hands to avoid transfer of microorganisms to other patients or environments. Category IB
 - e. Patient-Care Equipment
Handle used patient-care equipment soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures, contamination of clothing, and transfer of microorganisms to other patients and environments. Ensure that reusable equipment is not used for the care of another patient until it has been cleaned and reprocessed appropriately. Ensure that single-use items are discarded properly. Category IB
 - f. Environmental Control
Ensure that the hospital has adequate procedures for the routine care, cleaning, and disinfection of environmental surfaces, beds, bedrails, bedside equipment, and other frequently touched surfaces, and ensure that these procedures are being followed. Category IB
 - g. Linen
Handle, transport, and process used linen soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures and contamination of clothing, and that avoids transfer of microorganisms to other patients and environments. Category IB
 - h. Occupational Health and Bloodborne Pathogens
 - (1) Take care to prevent injuries when using needles, scalpels, and other sharp instruments or devices; when handling sharp instruments after

procedures; when cleaning used instruments; and when disposing of used needles. Never recap used needles, or otherwise manipulate them using both hands, or use any other technique that involves directing the point of a needle toward any part of the body; rather, use either a one-handed “scoop” technique or a mechanical device designed for holding the needle sheath. Do not remove used needles from disposable syringes by hand, and do not bend, break, or otherwise manipulate used needles by hand. Place used disposable syringes and needles, scalpel blades, and other sharp items in appropriate puncture-resistant containers, which are located as close as practical to the area in which the items were used, and place reusable syringes and needles in a puncture-resistant container for transport to the reprocessing area. Category IB(2) Use mouthpieces, resuscitation bags, or other ventilation devices as an alternative to mouth-to-mouth resuscitation methods in areas where the need for resuscitation is predictable. Category IB

i. Patient Placement

Place a patient who contaminates the environment or who does not (or cannot be expected to) assist in maintaining appropriate hygiene or environmental control in a private room. If a private room is not available, consult with infection control professionals regarding patient placement or other alternatives. Category IB

3. **Airborne Precautions**

In addition to Standard Precautions, use Airborne Precautions, or the equivalent, for patients known or suspected to be infected with microorganisms transmitted by airborne droplet nuclei (small-particle residue [5 μm or smaller in size] of evaporated droplets containing microorganisms that remain suspended in the air and that can be dispersed widely by air currents within a room or over a long distance). Category IB

a. Patient Placement

Place the patient in a private room that has 1) monitored negative air pressure in relation to the surrounding areas, 2) 6 to 12 air changes per hour, and 3) appropriate discharge of air outdoors or monitored high-efficiency filtration of room air before the air is circulated to other areas in the hospital. Keep the room door closed and the patient in the room. When a private room is not available, place the patient in a room with a patient who has active infection with the same microorganism, unless otherwise recommended, but with no other infection. When a private room is not available and cohorting is not desirable, consultation with infection control professionals is advised before patient placement. Category IB

b. Respiratory Protection

Wear respiratory protection (N95 respirator) when entering the room of a patient with known or suspected infectious pulmonary tuberculosis. Susceptible persons should not enter the room of patients known or suspected to have measles (rubeola) or varicella (chickenpox) if other immune caregivers are available. If susceptible persons must enter the room of a patient known or suspected to have measles (rubeola) or varicella, they should wear respiratory protection (N95 respirator). Persons immune to measles (rubeola) or varicella need not wear respiratory protection. Category IB

- c. Patient Transport
Limit the movement and transport of the patient from the room to essential purposes only. If transport or movement is necessary, minimize patient dispersal of droplet nuclei by placing a surgical mask on the patient, if possible. Category IB
- d. Additional Precautions for Preventing Transmission of Tuberculosis:
Consult CDC “Guidelines for Preventing the Transmission of Tuberculosis in Health-Care Facilities” for additional prevention strategies.

4. Droplet Precautions

In addition to Standard Precautions, use Droplet Precautions, or the equivalent, for a patient known or suspected to be infected with microorganisms transmitted by droplets (large-particle droplets [larger than 5 μm in size] that can be generated by the patient during coughing, sneezing, talking, or the performance of procedures). Category IB

a. Patient Placement

Place the patient in a private room. When a private room is not available, place the patient in a room with a patient(s) who has active infection with the same microorganism but with no other infection (cohorting). When a private room is not available and cohorting is not achievable, maintain spatial separation of at least 3 ft between the infected patient and other patients and visitors. Special air handling and ventilation are not necessary, and the door may remain open. Category IB

b. Mask

In addition to wearing a mask as outlined under Standard Precautions, wear a mask when working within 3 ft of the patient. (Logistically, some hospitals may want to implement the wearing of a mask to enter the room.) Category IB

c. Patient Transport

Limit the movement and transport of the patient from the room to essential purposes only. If transport or movement is necessary, minimize patient dispersal of droplets by masking the patient, if possible. Category IB

5. Contact Precautions

In addition to Standard Precautions, use Contact Precautions, or the equivalent, for specified patients known or suspected to be infected or colonized with epidemiologically important microorganisms that can be transmitted by direct contact with the patient (hand or skin-to-skin contact that occurs when performing patient-care activities that require touching the patient's dry skin) or indirect contact (touching) with environmental surfaces or patient-care items in the patient's environment. Category IB

a. Patient Placement

Place the patient in a private room. When a private room is not available, place the patient in a room with a patient(s) who has active infection with the same microorganism but with no other infection (cohorting). When a private room is not available and cohorting is not achievable, consider the epidemiology of the microorganism and the patient population when determining patient placement. Consultation with infection control professionals is advised before patient placement. Category IB

b. Gloves and Handwashing

In addition to wearing gloves as outlined under Standard Precautions, wear gloves (clean, nonsterile gloves are adequate) when entering the room. During the course of providing care for a patient, change

gloves after having contact with infective material that may contain high concentrations of microorganisms (fecal material and wound drainage). Remove gloves before leaving the patient's room and wash hands immediately with an antimicrobial agent or a waterless antiseptic agent. After glove removal and handwashing, ensure that hands do not touch potentially contaminated environmental surfaces or items in the patient's room to avoid transfer of microorganisms to other patients or environments. Category IB

c. Gown

In addition to wearing a gown as outlined under Standard Precautions, wear a gown (a clean, nonsterile gown is adequate) when entering the room if you anticipate that your clothing will have substantial contact with the patient, environmental surfaces, or items in the patient's room, or if the patient is incontinent or has diarrhea, an ileostomy, a colostomy, or wound drainage not contained by a dressing. Remove the gown before leaving the patient's environment. After gown removal, ensure that clothing does not contact potentially contaminated environmental surfaces to avoid transfer of microorganisms to other patients or environments. Category IB

d. Patient Transport

Limit the movement and transport of the patient from the room to essential purposes only. If the patient is transported out of the room, ensure that precautions are maintained to minimize the risk of transmission of microorganisms to other patients and contamination of environmental surfaces or equipment. Category IB

e. Patient-Care Equipment

When possible, dedicate the use of noncritical patient-care equipment to a single patient (or cohort of patients infected or colonized with the pathogen requiring precautions) to avoid sharing between patients. If use of common equipment or items is unavoidable, then adequately clean and disinfect them before use for another patient. Category IB

f. Additional Precautions for Preventing the Spread of Vancomycin Resistance

Consult the HICPAC report on preventing the spread of vancomycin resistance for additional prevention strategies.

Revision to OSHA's Bloodborne Pathogens Standard

TECHNICAL BACKGROUND AND SUMMARY

April 2001

Background

The Occupational Safety and Health Administration published the Occupational Exposure to Bloodborne Pathogens standard in 1991 because of a significant health risk associated with exposure to viruses and other microorganisms that cause bloodborne diseases. Of primary concern are the human immunodeficiency virus (HIV) and the hepatitis B and hepatitis C viruses.

The standard sets forth requirements for employers with workers exposed to blood or other potentially infectious materials. In order to reduce or eliminate the hazards of occupational exposure, an employer must implement an exposure control plan for the worksite with details on employee protection measures. The plan must also describe how an employer will use a combination of engineering and work practice controls, ensure the use of personal protective clothing and equipment, provide training, medical surveillance, hepatitis B vaccinations, and signs and labels, among other provisions. Engineering controls are the primary means of eliminating or minimizing employee exposure and include the use of safer medical devices, such as needleless devices, shielded needle devices, and plastic capillary tubes.

Nearly 10 years have passed since the bloodborne pathogens standard was published. Since then, many different medical devices have been developed to reduce the risk of needlesticks and other sharps injuries. These devices replace sharps with non-needle devices or incorporate safety features designed to reduce injury. Despite these advances in technology, needlesticks and other sharps injuries continue to be of concern due to the high frequency of their occurrence and the severity of the health effects.

The Centers for Disease Control and Prevention estimate that healthcare workers sustain nearly 600,000 percutaneous injuries annually involving contaminated sharps. In response to both the continued concern over such exposures and the technological developments which can increase employee protection, Congress passed the ***Needlestick Safety and Prevention Act*** directing OSHA to revise the bloodborne pathogens standard to establish in greater detail requirements that employers identify and make use of effective and safer medical devices. That revision was published on Jan. 18, 2001, and became effective April 18, 2001.

SUMMARY

The revision to OSHA's bloodborne pathogens standard added new requirements for employers, including additions to the exposure control plan and keeping a sharps injury log. It does not impose new requirements for employers to protect workers from sharps injuries; the original standard already required employers to adopt engineering and work practice controls that would eliminate or minimize employee exposure from hazards associated with bloodborne pathogens.

The revision does, however, specify in greater detail the engineering controls, such as safer medical devices, which must be used to reduce or eliminate worker exposure.

EXPOSURE CONTROL PLAN

The revision includes new requirements regarding the employer's Exposure Control Plan, including an annual review and update to reflect changes in technology that eliminate or reduce exposure to bloodborne pathogens. The employer must:

- take into account innovations in medical procedure and technological developments that reduce the risk of exposure (e.g., newly available medical devices designed to reduce needlesticks); and
- document consideration and use of appropriate, commercially available, and effective safer devices (e.g., describe the devices identified as candidates for use, the method(s) used to evaluate those devices, and justification for the eventual selection).

No one medical device is considered appropriate or effective for all circumstances.

Employers must select devices that, based on reasonable judgment:

- will not jeopardize patient or employee safety or be medically inadvisable; and
- will make an exposure incident involving a contaminated sharp less likely to occur.

EMPLOYEE INPUT

Employers must solicit input from non-managerial employees responsible for direct patient care regarding the identification, evaluation, and selection of effective engineering controls, including safer medical devices. Employees selected should represent the range of exposure situations encountered in the workplace, such as those in geriatric, pediatric, or nuclear medicine, and others involved in direct care of patients.

OSHA will check for compliance with this provision during inspections by questioning a representative number of employees to determine if and how their input was requested.

Documentation of Employee Input

Employers are required to document, in the Exposure Control Plan, how they received input from employees. This obligation can be met by:

- Listing the employees involved and describing the process by which input was requested; or
- Presenting other documentation, including references to the minutes of meetings, copies of documents used to request employee participation, or records of responses received from employees.

RECORDKEEPING

Employers who have employees who are occupationally exposed to blood or other potentially infectious materials, and who are required to maintain a log of occupational injuries and illnesses under existing recordkeeping rules, must also maintain a sharps injury log. That log will be maintained in a manner that protects the privacy of employees. At a minimum, the log will contain the following:

- the type and brand of device involved in the incident;
- location of the incident (e.g., department or work area); and
- description of the incident.

The sharps injury log may include additional information as long as an employee's privacy is protected. The format of the log can be determined by the employer.

MODIFICATION OF DEFINITIONS

The revision to the bloodborne pathogens standard includes modification of definitions relating to engineering controls. Two terms have been added to the standard, while the description of an existing term has been amended.

Engineering Controls

Engineering Controls include all control measures that isolate or remove a hazard from the workplace, such as sharps disposal containers and self-sheathing needles. The original bloodborne pathogens standard was not

specific regarding the applicability of various engineering controls (other than the above examples) in the healthcare setting. The revision now specifies that “safer medical devices, such as sharps with engineered sharps injury protections and needleless systems” constitute an effective engineering control, and must be used where feasible.

Sharps with Engineered Sharps Injury Protections

This is a new term which includes non-needle sharps or needle devices containing built-in safety features that are used for collecting fluids or administering medications or other fluids, or other procedures involving the risk of sharps injury. This description covers a broad array of devices, including:

- syringes with a sliding sheath that shields the attached needle after use;
- needles that retract into a syringe after use;
- shielded or retracting catheters; and
- intravenous medication (IV) delivery systems that use a catheter port with a needle housed in a protective covering.

Needleless Systems

This is a new term defined as devices which provide an alternative to needles for various procedures to reduce the risk of injury involving contaminated sharps. Examples include:

- IV medication systems which administer medication or fluids through a catheter port using non-needle connections; and
- jet injection systems which deliver liquid medication beneath the skin or through a muscle.

SOURCE: Adapted from <http://www.osha.gov/needlesticks/needlefact.html>.

Bibliography

- 2000 Test Catalog. Mayo Medical Laboratory, Rochester, Minn., 1999.
- AABB Technical Manual, ed 15. American Association of Blood Banks, Bethesda, MD, 2005.
- Abbott Axsym System CK-MB: Abbott Laboratories Product Literature. Abbott Laboratories, Chicago, 1999.
- Abbott Axsym System Troponin I: Abbott Laboratories Product Literature. Abbott Laboratories, Chicago, 1997.
- Abrams, C: ADH-associated pathologies. *Medical Laboratory Observer* 25:25, 2000.
- Abramson, N and Melton, B: Leukocytosis: Basics of Clinical Assessment. American Academy of Family Physicians, November 1, 2000. Available at <http://www.aafp.org/afp/20001101/2053.html> (accessed July 11, 2008).
- Aetna Clinical Policy Bulletins: Urea Breath Testing for *H. pylori* Infection, 2006. Available at http://www.aetna.com/cpb/medical/data/100_199/0177.html (accessed July 11, 2008).
- Ahmed, A: Autoantibody detection in autoimmune diseases. *Advance for Administrators of the Laboratory* Oct:68, 1998.
- Alexander, D: Pseudocholinesterase Deficiency. Available at www.emedicine.com/med/topic1935.htm (accessed July 11, 2008).
- Alter, M, et al: Testing for Viral Hepatitis. Abbott Diagnostics Educational Services, Chicago, 1992.
- American Diabetes Association: Clinical practice recommendations 1998. *Diabetes Care* 21:S23, 1998.
- Appleyard, M, et al: A randomized trial comparing wireless capsule endoscopy with push enteroscopy for the detection of small-bowel lesions. *Gastroenterology* 119:1431, 2000.
- Arky, R, et al (eds): *Physician's Desk Reference*, ed 50. Medical Economics Company, Montvale, N.J., 1996.
- Ballard Medical Products: Kimberly-Clark PYtest C-Urea Breath Test. Available at www.kchealthcare.com (Accessed July 22, 2008).
- Ballinger, P, and Frank, E: *Merrill's Atlas of Radiographic Positions and Radiologic Procedures*, ed 10. Mosby, St. Louis, 2003.
- Banez, E, et al: Laboratory monitoring of heparin therapy—the effect of different salts of heparin on the activated partial thromboplastin time. *Am J Clin Pract* Oct:569, 1980.
- Barclay, L. and Vega, C.: *Transfusion Related Acute Lung Injury Defined*. Available at www.medscape.com (accessed 9/8/2007).
- Bard, BTA: *Product Literature*. Bard Diagnostic Sciences, Redmond, Wash., 1996.
- Baskin, L, and Hsu, R: Laboratory evaluation of proteinuria. *Medical Laboratory Observer* Nov:30, 1999.
- Becton Dickinson: *Understanding additives: Heparin*. Available at www.bd.com (accessed July 22, 2008).
- Berkow, R, et al (eds): *The Merck Manual of Diagnosis and Treatment*, ed 17. Merck Sharp & Dohme Research Laboratories, Rahway, N.J., 1999.
- Beutler, E, et al (eds): *Williams Hematology*, ed 7. McGraw-Hill, New York, 2005.
- Biochemistry of Neurotransmitters. Available at www.themedicalbiochemistrypage.org/nerves.html (accessed January 17, 2006).
- Bishop, ML, et al: *Clinical Chemistry Principles, Procedures, Correlations*, ed 5. Lippincott Williams & Wilkins, Philadelphia, 2005.
- Bladder cancer and biochemical assays. *Clinical Laboratory Strategies* 5:3, 2000.
- Bodor, G: New gold standard in cardiac markers. *Advance for the Laboratory* Jul: 43, 1998.
- Boyd, R, and Hoerl, B: *Basic Medical Microbiology*. Little, Brown, Boston, 1977.
- Braunstein, G: *HCG Testing Volume I: A Clinical Guide for the Testing of Human Chorionic Gonadotropin*. Abbott Diagnostics Educational Services, Chicago, 1993.
- Braunstein, G: *HCG Testing Volume II: Answers to Frequently Asked Questions About HCG Testing*. Abbott Diagnostics Educational Services, Chicago, 1991.
- Bridgen, M: Clinical Utility of the Erythrocyte Sedimentation Rate. *American Family Physician* 30:5, 1999. Accessed 9/23/07.

- Bringing homocysteine into your lab. *Clinical Laboratory Strategies* 3:1, 1998.
- Burtis, C, and Ashwood, E (eds): *Tietz Textbook of Clinical Chemistry*, ed 2. WB Saunders, Philadelphia, 1994.
- Calgary Laboratory Services: Blood collection tubes, order of draw, 2003. Available at: www.calgarylabservices.com (accessed March 6, 2005).
- Calvo, M, and Park Y: Changing phosphorus content of the U.S. diet: Potential for adverse effects on bone. *J Nutr* 126(4S): 1168S, 1996.
- Carpinito, G: Product technology brief: Enzyme immunoassay for bladder cancer. *Clinical Lab Products* Apr:32, 1999.
- Castellone, D: Coagulation: The good, the bad and the unacceptable. *Advance for Medical Laboratory Professionals* Nov:53, 1999.
- Cavanaugh, B: *Nurses' Manual of Laboratory and Diagnostic Tests*, ed 4. FA Davis, Philadelphia, 2003.
- Centers for Medicare and Medicaid Services: CLIA Program: Clinical Laboratory Improvement Amendments, March 24, 2005. Available at: www.cms.hhs.gov/clia/ (accessed April 3, 2005).
- Centre for Digestive Diseases: Urea Breath Test, 2003. Available at www.cdd.com.au/html/hospital/procedures/procedure%20descriptions/urea%20breath%20test.html (accessed July 22, 2008).
- Cevik, I, Turker, N., Ozver, H., Akdas, A.: Short Term Effect of Digital Rectal Exam on Serum Prostate Specific Antigen Levels: A Prospective Study. *European Urology* 29:4, 403–406, 1996. Available at www.ncbi.nlm.nih.gov/pubmed/8791045 (accessed 7/22/08).
- Chernecky, C, and Berger, B: *Laboratory Tests and Diagnostic Procedures*, ed 2. WB Saunders, Philadelphia, 1997.
- Christenson, R: The basics of bone. *Clinical Laboratory News* May:10, 1998.
- Christenson, R: Biochemical cardiac markers present and future. *Medical Laboratory Observer* Sept:26, 1999.
- Ciesla, B: Targeting the thalassemias. *Advance for Medical Laboratory Professionals* Apr:12, 2000.
- CLR: Table of critical limits, 2007–2008. Available at: www.clr-online.com (accessed 2008).
- Colombraro, G: *Pediatrics: Core Content at a Glance*. Lippincott–Raven, Philadelphia, 1998.
- Constantinescu, M, and Hilman, B: The sweat test for quantitation of electrolytes. *Lab Med* 27:472, 1996.
- Contraction Stress Test. Available at www.webmd.com/baby/contraction-stress-test (accessed July 22, 2008).
- Corbett, J: *Laboratory Tests and Diagnostic Procedures with Nursing Diagnosis*, ed 7. Prentice-Hall Health, Upper Saddle River, N.J., 2007.
- Corning Clinical Laboratories. *The 1996/1997 Reference Manual*. Corning Clinical Laboratories, Teterboro, N.J., 1996.
- Cunningham, V: A review of disseminated intravascular coagulation. *Medical Laboratory Observer* July:42, 1999.
- D'Amico, et al: Preoperative PSA Velocity and the Risk of Death from Prostate Cancer after Radical Prostatectomy. *NEJM* 351:2, 125–135, 2004.
- Davidsohn, I, and Henry, J (eds): *Todd-Sanford: Clinical Diagnosis by Laboratory Methods*, ed 15. WB Saunders, Philadelphia, 1994.
- Department of Health and Human Services, Office of Disease Prevention and Health Promotion: *Healthy People 2000*. Available at: www.healthypeople.gov (accessed 2005).
- Dictionary. Available at www.biology-online.org
- DiLeo, G.: Amniotic Fluid and the Biophysical Profile. Available at: www.gynob.com/biopamfl.htm (accessed July 22, 2008).
- Disorders of Neuromuscular Transmission. Available at: www.merck.com/mmpe/print/sec16/ch223/ch223b.html (Accessed July 22, 2008).
- Doshi, M: *Blood Gas and Electrolyte Regulation*. Colorado Association for Continuing Medical Laboratory Education, Denver, 1997.
- Dubin, D: *Rapid Interpretation of EKGs*. C.O.V.E.R. Publishing, Tampa, Fla., 1989.
- Dutton, AG, Norcutt, TA, and Torres, L: *Basic Medical Techniques and Patient Care in Imaging Technology*, ed 6. Lippincott, Williams & Wilkins, Philadelphia, 2003.
- Eastman, G, et al: *Getting Started in Clinical Radiology*. Thieme Medical Publishers, New York, 2006.

- eMedicine: Microscopic polyangiitis, 2003. Available at: www.emedicine.com/med/topic2931.htm (Accessed July 22, 2008).
- Estimating Coronary Heart Disease (CHD) Risk Using Framingham Heart Study Prediction Score Sheets. Available at www.nhlbi.nih.gov/about/framingham/riskabs.htm (Accessed July 22, 2008).
- Falk, RA, and Miller, S: Clinical evaluation of osteoporosis. *Advance for Administrators of the Laboratory* May;57, 1999.
- First blood test for congestive heart failure wins FDA clearance. *Clinical Laboratory Strategies* 5:1, 2000.
- Fischbach, F: *A Manual of Laboratory and Diagnostic Tests*, ed 7. Lippincott Williams & Wilkins, Philadelphia, 2004.
- Fischbach, F: *Nurses' Quick Reference to Common Laboratory and Diagnostic Tests*, ed 4. Lippincott-Raven, Philadelphia, 2005.
- Gearhart, P.: *Biophysical Profile, Ultrasound*. Last updated June 10, 2005. Available at www.emedicine.com/radio/TOPIC758.HTM (accessed July 22, 2008).
- Gantzer, M: The value of urinalysis: An old method continues to prove its worth. *Clinical Laboratory News* Jan;14, 1998.
- Gerson, M: *Cardiac Nuclear Medicine*, ed 3. McGraw-Hill, New York, 1997.
- Gill, K: *Abdominal Ultrasound: A Practitioner's Guide*. WB Saunders, Philadelphia, 2001.
- Golish, J: *Diagnostic Procedure Handbook with Key Word Index*. Lexi-Company, Cleveland, Ohio, 1992.
- Green, R: Macrocytic and marrow failure anemias. *Lab Med* 30:595, 1999.
- Gregersen, P: Tracking Down RA Genes. Available at www.arthritis.org/research/researchupdate/04march_april/tracking.asp (accessed July 22, 2008).
- Gruenewald, J, et al (eds): *PDR for Herbal Medicines*, ed 2. Medical Economics Company, Montvale, N.J., 2000.
- Guidelines for Audiologic Assessment of Children from Birth to 5 Years of Age. Available at www.asha.org/docs/pdf/GL2004-00002.pdf (Accessed July 22, 2008).
- Gunderman, R: *Essential Radiology*, ed 2. Thieme Medical Publishers, New York, 2006.
- Hautmann, S, et al: Supersensitive Prostate Specific Antigen (PSA) in Serum of Women with Benign Breast Disease or Breast Cancer. *Anticancer Research*: 20, 3B, 2151-2154, 2000. Available at www.ncbi.nlm.nih.gov/pubmed/10928169 (Accessed July 22, 2008).
- Hearing Assessment. Available at www.asha.org/public/hearing/testing/assess.htm (Accessed July 22, 2008).
- Hennerici, M, and Neiserberg-Heusler, D: *Vascular Diagnosis with Ultrasound*. Thieme Medical Publishers, New York, 1998.
- Hicks, J, and Boeckx, R: *Pediatric Clinical Chemistry*. WB Saunders, Philadelphia, 1984.
- Hoeltke, L: *Phlebotomy: The Clinical Laboratory Manual Series*. Delmar Thomson Learning, Albany, N.Y., 1995.
- Homocysteine vs cholesterol: Competing views or a unifying explanation of arteriosclerotic cardiovascular disease. *Lab Med* 29:410, 1998.
- Hopfer Deglin, J, and Hazard Vallerand, A: *Davis's Drug Guide for Nurses*. FA Davis, Philadelphia, 2005.
- Howard, V: *Age Specific Guidelines*. Champlain Valley Physicians Hospital Medical Center, Plattsburgh, N.Y., 2000.
- hs-CRP: Detecting the Inflammation of Silent Atherosclerosis. Dade Behring Inc., Newark, N.J., 1999.
- hs-CRP to Improve Cardiac Risk Assessment. Dade Behring Inc., Newark, N.J., 1999.
- Ikanomova, K: Inflammation and Metabolic Syndrome. *Turkish Journal of Endocrinology & Metabolism* 3:85-89, 2004.
- Importance of Urinalysis: Lab Notes. Becton Dickinson Vacutainer Systems, Franklin Lakes, N.J., 1996.
- Inoue, S.: Leukocytosis. Available at www.emedicine.com/ped/topic1303.htm (Accessed July 23, 2008).
- International Medicine Clinic Research Consortium: Effect of Digital Rectal Examination on Serum Prostate Antigen in a Primary Care Setting 155:4, 1995. Available at <http://archinte.ama-assn.org/cgi/content/abstract/155/4/389> (Accessed July 23, 2008).
- Izbicki, G., et al: Transfusion related Leukocytosis in Critically Ill Patients. *Critical Care Medicine*, 32(2):439-442, Feb 2004. Available at www.ccmjournal.com (accessed August 19, 2007).

- Jacobs, D, et al: *Laboratory Test Handbook*, ed 5. Lexi-Comp, Hudson, Ohio, 2001.
- Jaffe, M, and McVan, B: *Davis's Laboratory and Diagnostic Test Handbook*. FA Davis, Philadelphia, 1997.
- Johns Hopkins Prostate Bulletin. Available at www.hopkinsprostate.com (accessed 4/20/06).
- Kandarian, P: ThinPrep imaging follows ThinPrep PAP to market. *Clinical Laboratory Products*, May;37, 2000.
- Kaplan, L, and Sawin, C: *Laboratory Support for the Diagnosis and Monitoring of Thyroid Disease*. National Academy of Clinical Biochemistry, Washington, D.C., 1996.
- Kee, J: *Laboratory and Diagnostic Tests with Nursing Implications*, ed 5. Appleton & Lange, Stamford, Conn., 1999.
- King, D: New methods facilitating Down's syndrome screening. *Advance for Laboratory Professionals* May;8, 2000.
- Kirschner, C, et al: *Current Procedural Terminology 2001*. AMA Press, Chicago, 2000.
- Koepke, J: Update on reticulocyte counting. *Lab Med* 30:339, 1999.
- Lab Corp: *Laboratory testing information*, 200. Available at: www.labcorp.com (Accessed 2008).
- Labtestsonline.org
- Landicho, H: Product technology brief: Urine assay quantitates bladder tumor antigen. *Clinical Lab Products* May;46, 2000.
- LaValle, J, et al: *Natural Therapeutics Pocket Guide*. Lexi-Comp, Hudson, Ohio, 2000.
- Lehman, C: *Saunders Manual of Clinical Laboratory Science*. WB Saunders, Philadelphia, 1998.
- Leukopenia. Available at www.wikipedia.org (accessed August 20, 2007).
- Lewandrowski, KB, et al: Cyst Fluid Analysis in the Differential Diagnosis of Pancreatic Cysts. A Comparison of Pseudocysts, Serous Cystadenomas, Mucinous Cystic Neoplasms, and Mucinous Cystadenocarcinoma. *Ann Surg*, 1993 Jan;217(1):41-7. Available at www.ncbi.nlm.nih.gov (Accessed May 16, 2006).
- Lewis, B, and Swain, P: Capsule endoscopy in the evaluation of patients with suspected small intestinal bleeding, a blinded analysis: The results of the first clinical trial. *Gastrointest Endosc* 53:AB70, 2001.
- Lewis, S, et al: *Medical Surgical Nursing Assessment and Management of Clinical Problems*, ed 6. Mosby, Philadelphia, 2003.
- Liquid Rho (D) Human IVIG for Hemolytic Disease in Newborns. *New Drugs Drug News P&T*, 2004 Mar;29(3):146.
- Liu, N, and Garon, J: A new generation of thyroid testing. *Advance for Administrators of the Laboratory* Nov;29, 1999.
- Lott, J: Clinical laboratory testing in hepatobiliary diseases. *Advance for Medical Laboratory Professionals* Jan;24, 2000.
- Lutz, C, and Przytulski, K: *Nutrition and Diet Therapy*. FA Davis, Philadelphia, 1997.
- Malarkey, L, and McMorro, M: *Nurses's Manual of Laboratory Tests and Diagnostic Procedures*, ed 2. WB Saunders, Philadelphia, 2000.
- Marking time with bone markers: New tests aid in managing osteoporosis. *Clinical Laboratory Strategies* Jul;3, 1998.
- Martin, F, and Clark, J: *Introduction to Audiology*, ed 8. Pearson Education Inc., Boston, MA, 2003.
- Masood, H: Menopause, hormones, and osteoporosis. *Advance for Administrators of the Laboratory* Feb;64, 2000.
- Massey, L: Error free urinalysis. *Advance for Medical Laboratory Professionals* Mar;19, 2000.
- McCall, R, and Tankersly, C: *Phlebotomy Essentials*, ed 4. JB Lippincott, Philadelphia, 2007.
- McEvoy, G, et al (eds): *American Hospital Formulary Service: AHFS Drug Information*. American Society of Hospital Pharmacists, Bethesda, Md., 1991.
- McMorro, ME, and Malarkey, L: *Laboratory and Diagnostic Tests: A Pocket Guide*. WB Saunders, Philadelphia, 1998.
- Medscape: Regular cola consumption linked to lower bone density in women, 2003. Available at: www.medscape.com/viewarticle/461898 (Accessed July 23, 2008).
- Meredith, J, and Rosenthal, N: Differential diagnosis of microcytic anemias. *Lab Med* 30:538, 1999.

- Miale, J: *Laboratory Medicine*, ed 5. Mosby, St. Louis, 1997.
- Miller, S: Preventing and detecting neural tube defects. *Medical Laboratory Observer* May;32, 1999.
- Montgomery, J: Improvements in prostate cancer detection. *Advance for Administrators of the Laboratory* Oct;66, 1999.
- Morris, E, and Liberman, L: *Breast MRI: Diagnosis and Intervention*. Springer, New York, 2005.
- Morris, R: New Highly Specific Autoantibody Markers in RA. Present Status and Future Prospects. International Rheumatology Network. Available at: http://www.rdlinc.com/pdf/articles/AutoantibodiesRA-DrMorris-10-5-06_4.pdf (Accessed July 23, 2008).
- Moving toward a more precise definition of myocardial infarction. *Clinical Laboratory Strategies* 5:1, 2000.
- MRI Registry Review Program. Medical Imaging Consultants, West Paterson, N.J., 1999.
- Myasthenia Gravis Foundation of America: Patient education materials. Available at: http://www.myasthenia.org/pe_informationalmaterials.cfm (Accessed July 23, 2008).
- Nageotte MP, et al: fFN testing in high risk asymptomatic women. *Am J Obstet Gynecol* 177:13, 1997.
- National Institute of Neurological Disorders and Stroke: Myasthenia Gravis Fact Sheet. Available at: www.ninds.nih.gov/disorders/myasthenia_gravis/detail_myasthenia_gravis.htm (Accessed July 23, 2008).
- NCCN Practice Guidelines in Oncology: Her2 Testing: Summary for Breast Cancer Patients, V.1.2007. Available at http://nccn.org/patients/fact_sheet.asp (Accessed July 23, 2008).
- NCEP Issues Major New Cholesterol Guidelines. National Institutes of Health, Bethesda, Md., 2001.
- Nester, E, et al: *Microbiology Molecules, Microbes, and Man*. Holt, Reinhart, & Winston, New York, 1973.
- A new era in newborn screening. *Clinical Laboratory Strategies* 5:1, 2000.
- New thyroid testing guidelines. *Clinical Laboratory Strategies* 6:2, 2001.
- The next evolution in chest pain evaluation. *Clinical Laboratory Strategies* 4:1, 1999.
- Nutritional Assessment of the Hospitalized Patient. Diasorin, Stillwater, Minn., 1998.
- Olds, S, et al: *Maternal Newborn Nursing*, ed 7. Prentice-Hall, Upper Saddle River, N.J., 2003.
- Omar, S., et al: Late Onset Neutropenia in Very Low Birth Weight Infants. *Pediatrics* 106:4, pe55, Oct. 2000. Available at www.pediatrics.aappublications.co. (accessed August 19, 2007).
- Pagana, K, and Pagana, T: *Diagnostic Testing and Nursing Implications: A Case Study Approach*, ed 5. Mosby, Philadelphia, 1999.
- Palkuti, H: International Normalized Ratio (INR): Clinical Significance and Applications. BioData Corporation, Horsham, Penn., 1995.
- Peaceman AM, et al: fFN testing in women with signs and symptoms of preterm labor. *Am J Obstet Gynecol* 170:20, 1994.
- Perrier, Arnaud, et al: D-dimer testing in suspected venous thromboembolism—An update. *QJM* 90:437, 1997.
- Peter, J: Use and Interpretation of Tests in Clinical Immunology, ed 8. Specialty Labs Inc., Santa Monica, Calif., 1991.
- Peter, J: Use and Interpretation of Tests in Infectious Disease, ed 4. Specialty Labs Inc., Santa Monica, Calif., 1996.
- Peter, J, and Reyes, H: Use and Interpretation of Tests in Allergy and Immunology. Specialty Labs Inc., Santa Monica, Calif., 1992.
- Peterson, P, and Cornacchia, M: *Anemia: Pathophysiology, clinical features, and laboratory evaluation*. Lab Med 30:463, 1999.
- Petrillo, M, and Sanger, S: *Emotionalized Care of Hospitalized Children: An Environmental Approach*, ed 2. JB Lippincott, Philadelphia, 1980.
- Phlebotomy Pages: New order of draw, 2003–2005. Available at: www.phlebotomypages.com/new_draw.htm (Accessed July 23, 2008).
- Prostate Specific Antigen (PSA) Best Practice Policy, American Urological Society. *Oncology* 14:2, 2000. Available from www.cancernetwork.com (accessed July 23, 2008).
- Quanta Lite CCP IgG ELISA package insert: Available at www.inovadx.com/Products/di_files/708790.html (Accessed July 23, 2008).

- Quest Diagnostics, Test Menu. Available at www.questdiagnostics.com (accessed July 23, 2008).
- Quinley, ED: *Immunohematology Principles and Practice*, ed 2. Lippincott–Raven, Philadelphia, 1998.
- Quinn, D, et al: D-dimers in the diagnosis of pulmonary embolism. *Am J Respir Crit Care Med* 159:1445, 1999.
- Reber, G, et al: Comparison of two rapid DDi assays for the exclusion of venous thromboembolism. *Blood Coagul Fibrinolysis* 9:387, 1998.
- Re-examining the ADA criteria for diagnosing diabetes. *Clinical Laboratory Strategies* Mar:3, 2000.
- Remaley, A, et al: Point of care testing of parathyroid hormone during the surgical treatment of hyperparathyroidism. *Medical Laboratory Observer* Apr:21, 1999.
- Ringel, M: Bladder tumor markers: Where do they fit in disease management? *Clinical Laboratory News* May:18, 1998.
- Rodak, B: *Diagnostic Hematology*. WB Saunders, Philadelphia, 1995.
- Rowlett, R: SI units for clinical data. In: *How Many? A Dictionary of Units of Measurement*. University of North Carolina at Chapel Hill, 2001. Available at: www.unc.edu/~rowlett/units/scales/clinical_data.html (accessed July 20, 2008).
- Rubaltelli, F, et al.: Transcutaneous Bilirubin Measurement: A Multicenter Evaluation of a New Device. *Pediatrics* 107:6, June 2000, 1264–1271. Available at <http://pediatrics.org> (Accessed July 23, 2008).
- Runge, V: *Contrast-Enhanced Clinical Magnetic Resonance Imaging*. The University Press of Kentucky, Lexington, 1996.
- Sainato, D: C-reactive protein and cardiovascular disease. *Clinical Laboratory News* Jun:1, 2000.
- Sandrick, K: Teasing out the value of new C-reactive protein test. *CAP Today* Jan:43, 2000.
- Savage, G, Charrier, M, and Vanhannen L: Bioavailability of soluble oxalate from tea and the effect of consuming milk with the tea. *Eur J Clin Nutr* 57:415, 2003.
- Schull, P: *Illustrated Guide to Diagnostic Tests*, ed 2. Springhouse Publishing, Springhouse, Penn., 1998.
- Seeram, E: *Computed Tomography: Physical Principles, Clinical Application, and Quality Control*, ed 2. WB Saunders, Philadelphia, 2001.
- Shackett, P: *Nuclear Medicine Technology — Procedures and Quick Reference*. Lippincott Williams & Wilkins, Philadelphia, 2000.
- Sharp, P, et al: *Practical Nuclear Medicine*, ed 2. Oxford Medical Publications, New York, 1998.
- Shimeld, LA: *Essentials of Diagnostic Microbiology*. Delmar Thomson Learning, Albany, N.Y., 1999.
- Snopek, A: *Fundamentals of Special Radiographic Procedures*, ed. 5. WB Saunders, St. Louis, 2006.
- Society of Nuclear Medicine: *Procedure Guidelines for C-14 Urea Breath Test*, 2001. Available at http://interactive.snm.org/docs/pg_ch07_0403.pdf (accessed July 23, 2008).
- Soldin, S, et al: *Pediatric Reference Ranges*, ed 3. AACCPress, Washington, D.C., 1999.
- Soloway, M, et al: Use of a new tumor marker, urinary NMP22, in the detection of occult or rapidly recurring transitional cell carcinoma of the urinary tract following surgical treatment. *J Urol* 156:363, 1996.
- Spruill, W, Wade, W, Cobb, H: Estimating Glomerular Filtration Rate with a Modification of Diet in Renal Disease Equation: Implications for Pharmacy. *Am J Health-Syst Pharm* 64(6):652–660, 2007. Available at www.medscape.com/viewarticle/555611 (Accessed July 23, 2008).
- Stein, H, Slatt, B, and Stein, R: *The Ophthalmic Assistant: A Guide for Ophthalmic Personnel*, ed 6. Mosby, St. Louis, 1994.
- Steine-Martin, EA, et al: *Clinical Hematology: Principles, Procedures, Correlations*. Lippincott–Raven, Philadelphia, 1998.
- Strasinger, S: *Urinalysis and Body Fluids*, ed 5. FA Davis, Philadelphia, 2008.
- Strasinger, S, and Di Lorenzo, M: *Phlebotomy Workbook for the Multiskilled Healthcare Professional*. FA Davis, Philadelphia, 1996.
- Sutton, I: Monitoring anticoagulation therapy. *Advance for Medical Laboratory Professionals* Jan:10, 2000.
- Taber's *Cyclopedic Medical Dictionary*, ed 20 (D. Venes, ed). FA Davis, Philadelphia, 2005.

- Tamul, K: Determining fetal-maternal hemorrhage with flow cytometry. *Advance for Laboratory Professionals* June:18, 2000.
- Tervaert, J: Infections in primary vasculitides. *Cleve Clin J Med* 69(S ID), 2002.
- Testing Services for Hereditary Motor Sensory Neuropathy. Athena Diagnostics, Worcester, Mass., 2000.
- The Gleason System. Available at <http://prostateinfo.com/patients/tests/index.asp> (Accessed July 23, 2008).
- Thelan, L, et al: *Critical Care Nursing: Diagnosis and Management*, ed 3. Mosby, St. Louis, Mo., 1998.
- Tietz, N: *Clinical Guide to Laboratory Tests*. AACC Press, Washington, D.C., 1995.
- Tilkian, S, et al: *Clinical and Nursing Implications of Laboratory Tests*, ed 5. Mosby, St. Louis, 1995.
- TNM Staging System. Available at <http://prostateinfo.com/patients/tests/staging.asp> (Accessed July 23, 2008).
- Transcutaneous Bilirubin Measurement is as Effective as Laboratory Serum Bilirubin Measurements at Detecting Hyperbilirubinemia. Available at www.med.umich.edu/pediatrics/ebm/cats/bili.htm (Accessed July 23, 2008).
- Tressler, K: *Clinical Laboratory and Diagnostic Tests: Significance and Nursing Implications*, ed 3. Appleton & Lange, Norwalk, Conn., 1995.
- Twiname, BG, and Boyd, S: *Student Nurse Handbook: Difficult Concepts Made Easy*. Appleton & Lange, Stamford, Conn., 1995.
- Understanding Gleason Grading. Available at www.phoenix5.org/Infolink/GleasonGrading.html (Accessed July 22, 2008).
- U.S. Food and Drug Administration: *Information for Healthcare Professionals Gadolinium-Based Contrast Agents for Magnetic Resonance Imaging* (marketed as Magnevist, MultiHance, Omniscan, OptiMARK, Prohance). Available at www.fda.gov/cder/drug/infosheets/hcp/gcca_200705.htm (Accessed July 23, 2008).
- Using FISH for prenatal diagnosis. *Clinical Laboratory Strategies* Mar:2, 2000.
- Uzunlar, H, Eroglu, A, and Bostan, H: Thoracic Epidural Anesthesia Combined with Remifentanyl-Propofol Without Muscle Relaxants in a Myasthenic Gravis Patient for Abdominal Surgery. *The Internet Journal of Anesthesiology*, 9:1, 2005. Available at <http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ija/vol9n1/thoracic.xml> (Accessed July 23, 2008).
- Van Dyne, R: Diagnosing common bleeding disorders. *Advance for the Administrators of the Laboratory* Oct:74, 1998.
- Van Leeuwen, A, and Perry, E: *Basic Principles of Chemistry: Techniques Using Alternate Measurements*. Colorado Association for Continuing Medical Laboratory Education, Denver, 2000.
- Vitros Chemistry System Test Methodology Manual. Ortho-Clinical Diagnostics, Rochester, N.Y., 1999.
- Von Schulthess, G: *Clinical Positron Emission Tomography*. Lippincott Williams & Wilkins, Philadelphia, 2001.
- Wasserman, M, et al: Utility of fever, white blood cells, and differential count in predicting bacterial infections in the elderly. *J Am Geriatr Soc* 37:537, 1989.
- WebMD: *Web MD Health Topics*, 2005. Available at: www.webmd.com (accessed 2005).
- Wentz, P: Chelation therapy: Conventional treatments. *Advance for Administrators of the Laboratory* May:74, 2000.
- Wentz, P: Homocyst(e)ine, the bad amino acid. *Advance for the Laboratory* May:71, 1999.
- Wentz, P: Megaloblastic anemias: Laboratory screening and confirmation. *Advance for Administrators of the Laboratory* Nov:57, 1999.
- Widman, FK, and Ittani, CA: *An Introduction to Clinical Immunology and Serology*. FA Davis, Philadelphia, 1998.
- Wikipedia: LEEP procedure. Available at: http://en.wikipedia.org/wiki/Loop_electrical_excision_procedure (accessed July 2, 2008).
- Wilk, A, and van Venrooij, W: The Use of Anti-cyclic Citrullinated Peptide (anti-CCP) Antibodies in RA. Available at www.rheumatology.org/publications/hotline/1003anticcp.asp (Accessed July 23, 2008).
- Wilson, D: *Nurses' Guide to Understanding Laboratory and Diagnostic Tests*. Lippincott Williams & Wilkins, Philadelphia, 1999.

- Winter, W: Evaluating calcium disorders. *Advance for Administrators of the Laboratory* Jul:30, 2000.
- Winter, W: Real time monitoring of diabetes. *Clinical Laboratory News* June:12, 2000.
- Wolf, P: Cardiac infarction markers: Do we need another one? ASCP Spring Teleconferences, Chicago, 1999.
- Wong, D, and Hess, C: *Wong and Whaley's Clinical Manual of Pediatric Nursing*, ed 5. Mosby, Philadelphia, 2000.
- Wright, M, and Dearing, L: The role of HLA testing in autoimmune disease. *Advance for Administrators of the Laboratory* Apr:81, 2000.
- Wu, J: Prostate cancer progress. *Advance for Administrators of the Laboratory* Jul:25, 1998.
- Yeomans, E, et al: Umbilical cord pH, pCO₂, and bicarbonate following uncomplicated term vaginal deliveries. *Am J Obstet Gynecol* 151:798, 1985.
- Young, D: *Effects of Drugs on Clinical Laboratory Tests*, ed 5. AACC Press, Washington, D.C., 2000.
- Young, D, and Friedman, R: *Effects of Disease on Clinical Laboratory Tests*, ed 4. AACC Press, Washington, D.C., 2001.
- Yu, H, and Berkel, H: Prostate-Specific Antigen (PSA) in Women. *J La State Med Soc*, 1999, Apr; 151(4) 209–213. Available at http://www.ncbi.nlm.nih.gov/pubmed/10234897?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum (Accessed July 23, 2008).

Index

A

- A/a gradient (alveolar/arterial gradient), 29–32
- a/A ratio (arterial/alveolar oxygen ratio), 29–32
- AAT (alpha₁-antitrypsin), 136–139
- AAT (alpha₁-antitrypsin) phenotype, 136–139
- Abdomen
- angiogram/arteriogram of, 57–61
 - computed tomography of, 403–407
 - FDG-PET scan of, 598–601
 - gastrointestinal blood loss scan and, 651–654
 - KUB study of, 770–772
 - laparoscopy of, 782–785
 - liver and spleen scan of, 800–803
 - lymph node sonography of, 1150–1152
 - Meckel's diverticulum scan of, 864–867
 - MRI of, 832–835
 - pelvic sonography of, 1155–1158
- Abdominal abscess, CT of, 404–407
- Abdominal aortic disease, MRI of, 844–846
- Abdominal malignancy, 936–938
- Abdominal mass, 783
- KUB study of, 770–772
 - laparoscopy of, 782–785
 - liver and spleen scan of, 800–803
 - MRI of, 832–835
- Abdominal obstruction, CT of, 404–407
- Abdominal pain
- acetaminophen intoxication and, 54–57
 - gastrointestinal blood loss scan, 651–654
 - KUB study of, 770–772
 - laparoscopy of, 985–988
 - Meckel's diverticulum scan for, 865–867
 - urine porphyrins and, 959–962
- Abdominal trauma/injury
- amylase levels with, 52–53
 - CT of, 403–407
 - laparoscopy of, 782–785
 - liver/spleen scan after, 800–803
 - peritoneal fluid analysis for, 936–938
 - ultrasonography after, 1155–1158
- Abdominal wall defect, fetal, AFP and, 613–617
- Abetalipoprotein deficiency, 606–608
- Abetalipoproteinemia
- apolipoprotein A and, 141–143
 - HDLC and LDLC levels in, 326–329
 - triglyceride levels and, 1108–1111
 - vitamin A and, 1227
 - vitamin E and, 1223–1224
- ABG (arterial blood gas), 221–232
- ABO blood group, 233–237
- ABO hemolytic reaction, transfusion related, 1269–1272
- Abortion
- AFP levels in, 615
 - human chorionic gonadotropin level in, 715
 - progesterone testing for, 989–990
- ABR (auditory brainstem response), 590
- Abrasion
- slit-lamp biomicroscopy of, 1061
- Abruptio placentae
- fibrin degradation product and, 618–619
 - ultrasonography for, 1136–1139
- Abscess, 79–82
- abdominal angiography of, 58–61
 - abdominal CT of, 404–407
 - brain CT of, 417–420
 - bronchoscopy for, 250–253
 - cancer antigen levels in, 284–285
 - carotid angiography of, 67–69
 - CT angiography of, 409–412
 - EEG determining, 563–564
 - gallium scan for, 636–638
 - kidney CT for, 442–445
 - liver and spleen scan for, 801–803
 - liver/biliary tract CT of, 412–416
 - mammography for, 862–864
 - MRI for, 837–839, 859–861
 - pancreatic CT of, 429–433
 - pelvic CT of, 433–437
 - pituitary CT of, 438–441
 - proctosigmoidoscopy for, 985–988
 - renogram for, 1040–1042
 - retrograde ureteropyelography for, 1045–1048
 - splenic CT of, 450–453
 - thoracic CT for, 454–456
 - ultrasonography for, 1143, 1150, 1159, 1162, 1164
 - WBC and differential in, 400–403
 - white blood cell scan for, 1231–1233
- Abscess drainage, breast ultrasonography for, 1143–1147
- Absolute value, 397
- Absolute white blood cell count, 362
- Absorptiometry, radiographic, 242–245

- Abuse. *See specific types, e.g.*, Drug abuse
- ACA (anticardiolipin antibody), 113–115
- Acalculous cholecystitis, hepatobiliary scan for, 701–704
- Acanthocyte, 363, 392
- Accessory spleen, 1164–1166
- AcChS (pseudocholinesterase), 1011–1012, 1030
- ACE (angiotensin-converting enzyme), 82–83, 133–134
- Acetaminophen, 54
lactic acid levels and, 777–779
toxicity of, 54–57
- Acetoacetic acid, 768
- Acetone, 768
- N*-Acetyl procainamide, 86–92
- Acetylcholine receptor (AChR) antibody, 1–3
- Acetylcholinesterase (AChE), 1030
amniotic fluid analysis and, 46
- Acetylsalicylic acid, 54–57
- Achalasia
barium swallow for, 160–162
capsule endoscopy for, 274–276
esophageal manometry for, 583
upper GI series for, 1172–1174
- AChE (acetylcholinesterase), 1030
amniotic fluid analysis and, 46
- Achondroplasia, 1028–1029
- AChR (acetylcholine receptor) antibody, 1–3
- Acid clearing, 583, 585
- Acid elution slide test, 772
- Acid fast bacilli culture and smear, 487
- Acid fast stain, 487, 678
- Acid hemolysis test, 685
- Acid perfusion, 582–583, 585
- Acid phosphatase, prostatic (AcP), 3–4
- Acid reflux test, 582–583
- Acid-base balance
blood gases and, 223–232
carbon dioxide and, 276–279
chloride and, 306–310
potassium and, 227–232
serum osmolality and, 899–902
sodium and, 1064–1067
- Acid-base disturbance, 225–232
- Acidosis, 224. *See also specific types, e.g.*, Ketoacidosis; Metabolic acidosis
calcium values in, 260–263
carbon dioxide levels in, 277–279
catecholamine levels in, 287–290
chloride values in, 308–310
diabetic. *See* Diabetic acidosis;
Diabetic ketoacidosis
ionized calcium values in, 265–267
ketone level in, 767–770. *See also* Ketoacidosis
- lactic. *See* Lactic acidosis
metabolic. *See* Metabolic acidosis
potassium levels and, 975–978
renal tubular. *See* Renal tubular acidosis
respiratory. *See* Respiratory acidosis
- Aciduria, methylmalonic, ketones and, 767–770
- Acoustic neuroma
evoked brain potentials in, 591–594
MRI for, 837–839
- Acquired angioedema, C4 complement and, 357–358
- Acquired aplastic anemia, 689–691
- Acquired hemolytic anemia, osmotic fragility and, 902–903
- Acquired immune deficiency syndrome (AIDS), 880–883. *See also* Human immunodeficiency virus (HIV)
alanine aminotransferase levels in, 13–15
gallium scan for, 636–638
mycobacteria culture/smear for, 488
osmotic fragility and, 902–903
platelet antibody and, 948–949
Pneumocystis jirovecii (carinii) and, 530–534
T-cell enumeration for, 292–293
viral culture for, 517–519
WBC and differential in, 400–403
zinc level in, 1235–1236
- Acquired methemoglobinemia, 874
- Acquired porphyria, 902–903, 960–962
- Acquired pyruvate kinase deficiency, 902–903
- Acrodermatitis enteropathica, 1234, 1235–1236
- Acromegaly
blood creatinine clearance test and, 477–479
calcium values in, 260–263
glucagon level in, 655–657
glucose levels in, 658–662
human growth hormone levels in, 683–684
insulin levels in, 745–747
phosphorus levels in, 939–942
TBG level in, 1098–1099
urinary calcium levels in, 268–271
urine creatinine clearance test and, 481–484
WBC and differential in, 400–403
- ACTH. *See* Adrenocorticotrophic hormone (ACTH)
- Actinomyces israelii*, 515–516
- Actinomyces* spp., 917
- Activated charcoal
anticonvulsant toxicity and, 261–263

- antidepressant drug toxicity and, 124–128
- antipsychotic toxicity and, 131–134
- digoxin toxicity and, 86–92
- haloperidol toxicity and, 131–134
- lithium toxicity and, 131–134
- methemoglobin toxicity and, 874–876
- Activated partial thromboplastin time (aPTT), 811, 925–929
- Activity intolerance, Holter monitor and, 707–709
- Acute cholecystitis, 797–799
- Acute gout, 940–942
- Acute hemolysis, 399–403
 - WBC and differential in, 400–403
- Acute hemolytic transfusion reaction, 1269–1270
- Acute hepatitis. *See* Hepatitis
- Acute immune-mediated transfusion reaction, 1269–1270
- Acute infection
 - transferrin level in, 1106–1108
 - zinc level in, 1235–1236
- Acute intermittent porphyria, 1097–1099
 - antidiuretic hormone and, 129–130
 - blood gas analysis in, 226–232
 - carbon dioxide levels in, 277–279
 - total cholesterol level in, 330–333
- Acute leukemia
 - amino acid levels in, urine test for, 40
 - LAP levels in, 795–797
 - pyruvate kinase levels in, 1020
- Acute myeloblastic leukemia, 174–177
- Acute myelogenous leukemia, 4
- Acute myeloid leukemia, 948–949
- Acute myocardial infarction
 - erythrocyte sedimentation rate and, 577–578
 - fibrinogen level in, 620–622
 - haptoglobin level in, 686–687
 - triglyceride levels and, 1109–1111
 - troponin level in, 1117–1118
- Acute myocardial infarction scan, 750–752
- Acute nephritis, 269–271
- Acute non-immune-mediated transfusion reaction, 1270–1271
- Acute pancreatitis
 - alanine aminotransferase levels in, 13–15
 - aldolase levels in, 18–19
 - calcium values in, 261–263
 - glucagon level in, 655–657
- Acute porphyrias, 41–43. *See also* Acute intermittent porphyria
- Acute poststreptococcal glomerulonephritis, 485–486
- Acute renal failure
 - BUN level in, 1178–1180
 - carbon dioxide levels in, 278–279
- Acute respiratory distress syndrome (ARDS), A/a gradient and a/A ratio in, 30
- Acute respiratory failure, 517–519
- Acute tubular necrosis
 - MRI for, 833–835
 - renogram for, 1040–1042
- Acute-phase inflammatory response, pre-albumin and, 982–984
- Acute-phase reaction
 - C3 and C4 complement and, 356–358
 - total complement and, 359–360
- Addison's disease
 - ACTH levels in, 10
 - aldosterone levels in, 20–22
 - blood gas analysis in, 227–232
 - calcium values in, 260–263
 - chloride values in, 308–310, 311–314
 - cortisol levels in, 465–467
 - DHEAS and, 542–543
 - eosinophil count in, 573–575
 - fecal fat and, 606–608
 - glucose levels in, 659–662
 - magnesium level and, 822–824
 - potassium levels and, 975–978, 980–982
 - renin value in, 1036–1039
 - sodium levels in, 1066–1067
 - WBC and differential in, 400–403
- Adenoma
 - aldosterone levels in, 20–22
 - cortisol levels in, 465–467
 - pituitary CT of, 438–441
 - thyroid scan for, 1090–1092
 - ultrasonography for, 1148–1149
- Adenomyosis, 855–857
- Adenopathy, 852–854
- Adenosine diphosphate (ADP), 902–903
- Adenosine triphosphate (ATP), 902–903
- Adenovirus, 517–519
- ADH. *See* Antidiuretic hormone (ADH)
- ADHD (attention-deficit hyperactivity disorder), 126–128
- Adhesion
 - hysterosalpingography and, 727–730
 - laparoscopy and, 782–785, 785–788
- ADNase-B (antideoxyribonuclease-B), 122–124
- Adnexal torsion, 1136–1139, 1156–1158
- Adnexal tumor, 1156–1158
- Adolescent
 - age-specific communication and, 1266–1267
 - amino acid screen in, 39–41
- ADP (adenosine diphosphate), 902–903

- Adrenal adenoma
 ACTH levels in, 10
 adrenal angiography of, 63–65
 cortisol levels in, 465–467
 kidney CT for, 442–445
- Adrenal cancer, 10
- Adrenal carcinoma
 adrenal angiography of, 63–65
 glucose levels in, 659–662
- Adrenal cortex, 542
- Adrenal failure
 sodium levels and, 1068–1071
- Adrenal gland
 angiography of, 62–65
 scintiscan of, 4–7
- Adrenal gland disorder, 129–130
- Adrenal hyperfunction
 cortisol levels in, 464–467
- Adrenal hyperplasia
 abdominal CT of, 404–407
 adrenal angiography of, 63–65
 adrenal scan for, 5
 kidney CT for, 442–445
 testosterone and, 1085–1086
- Adrenal hypofunction, 465–467
- Adrenal insufficiency, 9–10
 DHEAS and, 542–543
 glucose tolerance test for, 666–669
 prolactin level in, 991–993
- Adrenal tumor
 abdominal CT of, 404–407
 DHEAS and, 542–543
 estradiol level in, 589–590
- Adrenocarcinoma, 916
- Adrenocortical hyperfunction
 amino acid levels in, blood test for, 37–38
 human growth hormone levels in, 683–684
- Adrenocortical insufficiency, 822–824
- Adrenocortical tumor, 1085–1086
- Adrenocorticosteroid, 400–403
- Adrenocorticosteroid insufficiency, 900–902
- Adrenocorticotrophic hormone (ACTH)
 challenge tests and, 7–12
 DHEAS and, 542
 stimulated, rapid test, 464–467
- Adrenogenital syndrome, 466–467
- Adult
 age-specific communication and, 1267–1268
 amino acid screen in, 39–41
 beta₂-microglobulin levels in, 879
 blood gas analysis in, 221–232
 calcium values in, 259–260
 carbon dioxide measurement in, 276
 complement proteins in, 356
 DHEAS and, 542–543
 fibrinogen level in, 620–622
 follicle-stimulating hormone level in, 628
 glucose levels in, 657
 G6PD levels and, 662
 haptoglobin level in, 685
 metanephrine levels in, 871
 osteoporosis in, 344
 radiography of, 1028–1029
 reticulocyte count in, 1042
 sodium levels in, 1065
 total cholesterol level in, 329–333
 total CK in, 472
 uric acid level in, 1185–1188
 vanillylmandelic acid level in, 1203
 vitamin B₁₂ level in, 1217
 vitamin C level in, 1227
 vitamin E deficiency and, 1222–1224
 zinc deficiency in, 1234
- Adult lymphoblastic (T-cell) leukemia, HTLV-I and, 722–724
- Adulterant, 546
- Adult Treatment Panel III (ATP III), cholesterol in, HDL, LDL, 326
- AEP (auditory evoked potential), 590–594
- Aeromonas* spp., 507–509
- Aerosol lung scan, 807
- AFI (amniotic fluid index), 1135–1139
- Afibrinogenemia
 aPTT in, 926–929
 prothrombin time and, 1008–1011
- AFP. *See* Alpha₁-Fetoprotein (AFP)
- A/G ratio (albumin/globulin ratio), 15–18
- Agammaglobulinemia, 734–735
- Agap (anion gap), 83–86
- Agenesis, of pulmonary artery, 844–846
- Age-specific communication, 1265–1268
- Agglutination test, and blood typing, 233
- Agglutinin titers. *See* Cold *entries*
- Aging adult
 DHEAS and, 542–543
 pulmonary function study of, 1016
 Schirmer tear test for, 1055–1056
 syphilis serology testing for, 1082–1083
- Agitation, antidepressant toxicity and, 124–128
- Agranulocytosis
 bone marrow biopsy and, 173–177
 procainamide toxicity and, 86–92
- A-hemolytic streptococcus, 501
- AIDS. *See* Acquired immune deficiency syndrome (AIDS)
- Airborne precautions, 1283–1284, 1287–1288
- Airborne transmission of pathogen, 1278
- Air-contrast barium enema, 157–159
- Airway obstruction, 277–279

- Airway resistance, plethysmography and, 950–954
- Airway-reactive disorder, 1015–1017
- Akinesia, 239–241
- Alanine, 39–41
- Alanine aminotransferase (ALT), 13–15
- Albright-type renal disease, 980–982
- Albumin (Alb), 15–18, 876. *See also*
- Microalbumin
 - calcium and, 259
 - FT₃ and, 1112
 - FT₄ and, 1099
 - glycated, 631–633
 - macroaggregated, in lung perfusion scan, 804
 - prealbumin and, 983
 - protein fractions and, 996
 - protoporphyrin and, 575
 - T₄-binding, 1097
 - total T₃ and, 1114
 - total T₄ and, 1101
 - units of, 996
 - urine, 876–879
 - zinc level and, 1235–1236
- Albumin/globulin ratio (A/G ratio), 15–18
- Alcohol abuse, 380–382, 544–547
- Alcohol aminotransferase levels in, 13–15
- aldosterone levels in, 20–22
- effect on EEG, 563
- FDG-PET scan imaging and, 599
- GGT levels with, 670–672
- glucose levels and, 659–662
- insulin levels with, 745–747
- lactic acid levels and, 777–779
- PET scan and, 964, 967, 971
- plethysmography and, 951
- testosterone and, 1085–1086
- Alcoholic myopathy, 205–208
- Alcoholism
- amylase levels in, 52–53
 - antimitochondrial/antismooth muscle antibody in, 101–102
 - bilirubin levels, 164–166
 - calcium release and, 257
 - chloride values in, 311–314
 - ferritin level in, 609–610
 - folate level in, 626–628
 - follicle-stimulating hormone level in, 629–631
 - HDLC level in, 326–329
 - hepatobiliary scan and, 702
 - hyperlipoproteinemia and, 800
 - immunoglobulin E level in, 734–735
 - ketone level in, 767–770
 - lactate dehydrogenase levels in, 775–776
 - magnesium level and, 822–824, 825–828
 - peripheral neuropathy and, 566–567
 - platelet count in, 380–382
 - potassium levels and, 975–978
 - prealbumin and, 983–984
 - protein level in, 996–998
 - RBC indices in, 389–391
 - RBC morphology in, 393–396
 - reticulocyte count for, 1043–1044
 - skeletal muscle CK-MM and, 474–475
 - total cholesterol level in, 330–333
 - triglyceride levels and, 1109–1111
 - uric acid level in, 1186–1188
 - vitamin B₁ and, 1227, 1228
 - vitamin B₆ and, 1228
 - vitamin B₁₂ and, 1218–1219
 - vitamin C and, 1228
 - WBC and differential in, 399–403
 - withdrawals from, phosphorous levels and, 940–942
- Aldolase (ALD), 18–19
- Aldosterone, 19–22. *See also*
- Hyperaldosteronism;
 - Hypoaldosteronism
- potassium levels and, 975–978
- Alkali ingestion, 84–86, 227–232
- Alkaline phosphatase (ALP)
- importance of, 795
 - isoenzyme and, 23–26
 - osteocalcin levels and, 903
 - peritoneal fluid and, 936–938
- Alkalosis
- anion gap and, 84–86
 - blood gas analysis in, 225
 - calcium values in, 261–263
 - carbon dioxide levels in, 278–279
 - chloride values in, 308–310
 - metabolic. *See* Metabolic alkalosis
 - potassium levels and, 975–978
 - respiratory. *See* Respiratory alkalosis
- Allen test, 1259
- Allergen profile, 26–28
- Allergen-specific immunoglobulin E, 26–28
- Allergic alveolitis, extrinsic, 727
- Allergic rhinitis, 27–28
- Allergy
- dye, 624. *See also* Iodinated dye(s)
 - eosinophil count in, 573–575
 - immunoglobulin levels with, 27–28
 - insulin, 748
 - intravenous pyelography and, 756
 - latex, 27–28, 789
 - pulmonary function study for, 1016–1017
 - shellfish. *See* Shellfish allergy
 - transfusion, 1269–1272
 - WBC and differential in, 400–403
- Alloantibody, platelet, 948–949
- Alloimmune disorder, platelet antibodies, 948–949

- Alloimmunization, transfusion related, 1272
- ALP. *See* Alkaline phosphatase (ALP)
- Alpha-amino-adipic acid, 39–41
- Alpha-amino-*N*-butyric acid, 39–41
- Alpha₁-antitrypsin, 136–139
- Alpha₁-antitrypsin phenotyping, 136–139
- Alpha-chain substitution, 690
- Alpha₁-fetoprotein (AFP), 613–617
 - amniotic fluid analysis and, 47, 48
 - quad-marker testing and, 613, 715
 - triple-marker testing and, 613, 614, 715
- Alpha₁-globulin, 996–998
- Alpha₂-globulin, 996–998
- Alpha-microglobulin-1 protein, placental, 47
- ALS (amyotrophic lateral sclerosis)
 - electromyography for, 566–567
 - muscle biopsy for, 205–208
- ALT (alanine aminotransferase), 13–15
- Altitude
 - FT₃ and, 1112–1113
 - hematocrit in, 369–372
 - hemoglobin in, 374–378
- Alveolar hemorrhage, 103–104
- Alveolar/arterial gradient (A/a gradient), 29–32
- Alveolitis, extrinsic allergic, 727
- Alzheimer's disease
 - FDG-PET scan for, 598–601
 - MRI for, 837–839
 - PET scan for, 963–966
- Alzheimer's disease markers, 32–34
- AMA (antimitochondrial antibody), 100–102
- AMA (antimitochondrial muscle antibody), 100–102
- Amblyopia
 - Intraocular muscle function and, 750–752
 - visual field test for, 1215–1217
- Ambulatory monitoring, 707–709
- Amebiasis, 908–909
- Amebic abscess
 - liver and spleen scan of, 801–803
 - MRI of, 832–835
- Amebic colitis, 603–604
- Amenorrhea
 - bone mineral densitometry and, 243
 - laparoscopic evaluation of, 786
 - prolactin and, 991
- Amethopterin, 739–742
- Amikacin, 92–96
- Amino acid, ammonia and, 1004
- Amino acid screen
 - blood specimen for, 35–38
 - urine specimen for, 39–41
- Aminoacidopathy, 37–38
- Aminoaciduria, 40
- gamma-Amino-butyric acid, 39–41
- Aminoglycoside, 92–96, 880–883
- gamma-Aminoiso-butyric acid, 39–41
- Aminolevulinic acid dehydrase
 - deficiency, 41–43
- Amitriptyline, 124–128
- Ammonia, 43–45
 - amino acids and, 1004
 - peritoneal fluid and, 936–938
 - urea and, 1004
- Amniocentesis, 792. *See also* Amniotic fluid analysis
- Amniotic fluid analysis, 45–51
 - AmniSure in, 47
 - fern test in, 46
 - nitrazine test in, 46
- Amniotic fluid index (AFI), 1135
- AmniSure, 47
- Amphetamine abuse, 544–547
- Amylase, 51–53, 936–938
- Amyloidosis
 - albumin/globulin ratio, 16–18
 - alkaline phosphatase levels in, 24–26
 - beta₂-microglobulin levels in, 880–883
 - complement protein levels in, 357–358
 - D-xylose tolerance test for, 547–550
 - fecal fat and, 606–608
 - gastric emptying scan for, 643–645
 - immunofixation electrophoresis for, 731
 - liver and spleen scan for, 801–803
 - liver biopsy for, 194–197
 - lung biopsy for, 198–201
 - osmotic concentration and, 900–902
- Amyloidosis infiltration, kidney biopsy in, 191
- Amyotrophic lateral sclerosis (ALS)
 - electromyography for, 566–567
 - muscle biopsy for, 205–208
- ANA (antinuclear antibody), 104–108
- Anal canal mucosa, proctosigmoidoscopy and, 985–988
- Anal culture, 492–497
- Anal fissure
 - fecal analysis for, 603–604
 - proctosigmoidoscopy for, 985–988
- Anal fistula, 985–988
- Anal papillae, proctosigmoidoscopy and, 985–988
- Analbuminemia, 16–18
- Analgesic drugs, 54–57
- Analoscopy, 985–988
- Anaphylaxis, 1270
 - immunoglobulin levels in, 27–28

- WBC and differential in, 400–403
- Anastomosis, proctosigmoidoscopy and, 985–988
- Ancylostoma duodenale* infection, 908–909
- Androgen resistance syndrome, 1085–1086
- Anemia, 373–378, 383–388, 457–458
 - aldolase levels in, 18–19
 - alkaline phosphatase levels in, 25–26
 - amino acid levels in, urine test for, 40
 - antithyroglobulin/antithyroid peroxidase antibody in, 112–113
 - aplastic. *See* Aplastic anemia
 - apolipoprotein B and, 141–143
 - bilirubin levels in, 164–166
 - blood gas analysis in, 226–232
 - bone marrow biopsy for, 174–177
 - calcitonin stimulation test for, 257–259
 - cholinesterase enzyme in, 1030–1032
 - complement protein levels in, 357–358, 359–360
 - copper levels in, 461–463
 - DAT and, 459–460
 - drug-induced, 457–458
 - dyserythropoietic, 683
 - PNH and, 685
 - erythrocyte sedimentation rate and, 577–578
 - erythropoietin level in, 581–582
 - fecal fat and, 606–608
 - ferritin level in, 609–610
 - folate level in, 626–628
 - free erythrocyte protoporphyrin test for, 576–577
 - gastric acid stimulation test and, 640–642
 - gastrin stimulation test for, 645–647
 - glycated hemoglobin A_{1c} and, 673–674
 - G6PD levels in, 663
 - Ham's test for, 683
 - hematocrit in, 369–372
 - hemoglobin C Harlem, 1060–1061
 - hemoglobin electrophoresis for, 689–691
 - hemoglobin in, 374–378
 - hemolytic. *See* Hemolytic anemia
 - hemosiderin levels in, 692–693
 - human chorionic gonadotropin level in, 716–717
 - hypochromic, 461–463
 - RBC indices in, 390–391
 - total iron-binding capacity and, 765–766
 - intrinsic factor antibody and, 759–760
 - iron level in, 761. *See also* Iron-deficiency anemia
 - lactate dehydrogenase levels in, 775–776
 - LAP levels in, 795–797
 - LDLC level in, 327–329
 - lead intoxication and, 790
 - macrocytic, 389–391
 - megaloblastic. *See* Megaloblastic anemia
 - microangiopathic, 692–693
 - microcytic, 461
 - nonspherocytic
 - G6PD levels in, 663
 - pyruvate kinase levels in, 1020
 - osmotic fragility and, 902–903
 - pernicious. *See* Pernicious anemia
 - platelet count in, 379–382
 - posthemorrhagic, 379–382
 - pseudocholinesterase level in, 1011–1012
 - pulse oximetry and, 1018–1019
 - pyruvate kinase levels in, 1020
 - RBC indices in, 389–391
 - RBC morphology in, 393–396
 - refractory, 393–396
 - reticulocyte count for, 1043–1044
 - sickle cell screen and, 1060. *See also* Sickle cell anemia
 - sideroblastic. *See* Sideroblastic anemia
 - total cholesterol level in, 331–333
 - total iron-binding capacity and, 765–766
 - transferrin level in, 1106–1108
 - upper GI series for, 1172–1174
 - uric acid level in, 1189–1191
 - vitamin B₁₂ and, 1218–1219
 - vitamin C and, 1228
 - vitamin E and, 1222–1224
 - WBC and differential in, 399–403
 - zinc level in, 1234–1236
- Anencephaly, AFP and, 446–449
- Anesthesia
 - cholinesterase deficiency and, 1030
 - pseudocholinesterase deficiency and, 1011–1012
 - uterine fibroid embolization and, 1199–1202
- Aneurysm, 79–82
 - abdominal angiography of, 58–61
 - abdominal CT of, 404–407
 - aortic. *See* Aortic aneurysm
 - arterial
 - abdominal angiography of, 58–61
 - carotid angiography of, 67–69
 - brain CT of, 417–420
 - carotid angiography of, 67–69
 - cerebral, 837–839
 - coronary angiography of, 70–73
 - CT angiography of, 408–412

- Aneurysm (*continued*)
 echocardiography for, 551–554
 esophagogastroduodenoscopy and, 587
 fluorescein angiography for, 623–625
 fundus photography for, 634–635
 kidney CT for, 441–445
 left ventricle, 886
 MRI for, 833–835, 836–839, 859–861
 myocardial infarction scan and, 886
 PET scan for, 963–966
 pituitary CT of, 437–441
 pulmonary angiography of, 74–77
 renal artery, 79–82, 442–445
 transesophageal echocardiography of, 555–557
 ultrasonography for, 1129–1131
 ventricular, 551–554
- Angiitis, 103–104
- Angina pectoris, 1117–1118
- Angiodysplasia, 651–654
- Angioedema, 357–358
- Angiography
 computed tomography, 408–412
 fluorescein, 623–625
 magnetic resonance, 829–831, 836–838
 of pancreas, 851
 of pelvis, 855
 of abdomen, 57–61
 of adrenal gland, 62–65
 of heart, 70–73
 of kidney, 78–82
 of neck/cervical area, 66–69
 of pulmonary vasculature, 74–77
 patient's age as factor in, 59, 63, 67, 71, 75, 79
 sensitivity to iodinated dye and, 59, 63, 67, 71, 74, 79
- Angioplasty, 58, 66
- Angiotensin, 1035–1036
- Angiotensin-converting enzyme (ACE), 82–83, 133–134
- Angiotensinogen, 1035–1036
- Angle-closure glaucoma, 752–755
- Anion, 974
- Anion gap, 83–86
- Anisocytosis, 363, 392
- Ankle, arthrogram of, 143–146
- Ankle pressure, plethysmography and, 950–954
- Ankylosing rheumatoid spondylitis
 copper levels in, 462–463
 human leukocyte antigen and, 721–722
 MRI in, 848
 radiography in, 1028
 spine CT in, 446
- Anomalous atrioventricular excitation, 595–597
- Anorchia, 815–816
- Anorectal abscess, 985–988
- Anorectal infection, 517–519
- Anorexia nervosa
 apolipoprotein B and, 141–143
 bilirubin levels in, 164–166
 blood gas analysis in, 226–232
 follicle-stimulating hormone level in, 629–631
 gastric emptying scan for, 643–645
 human growth hormone levels in, 683–684
 LDLC level in, 327–329
 luteinizing hormone secretion and, 815–816
 potassium levels and, 976–978
 prolactin level in, 991–993
 total cholesterol level in, 330–333
 triglyceride levels and, 1109–1111
 WBC and differential in, 400–403
- Anovulation
 DHEAS and, 542–543
 testosterone and, 1085–1086
- Anoxia, 226–232
- ANP (atrial natriuretic peptide), 152–153, 254
- ANS (autonomic nervous system), 288–290
- Anserine, 39–41
- Antacids, 822–824
- Anterior chamber
 gonioscopy of, 675–677
 split-lamp biomicroscopy of, 1061
- Anterior pituitary hypofunction, 629–631
- Anti-A antibody, 233
- Antianginal effectiveness, 595–597
- Antiarrhythmic drugs, 86–92
- Antiarrhythmic effectiveness, 595–597
- Anti-B antibody, 233
- Antibiotic therapy, 92–96
 throat/nasopharyngeal culture and, 510
 urine culture and, 512
 vitamin K and, 1225–1226
- Antibody(ies). *See also* Immunoglobulin *entries*
 acetylcholine receptor, 1–3
 anticentromere, 104–108
 anti-cyclic citrullinated peptide, 96–98
 anti-DNA, 104–108
 antiextractable nuclear antigen, 104–108
 anti-glomerular basement membrane, 99–100
 antimitochondrial and antismooth muscle, 100–102
 antineutrophilic cytoplasmic, 102–104

- antinuclear, 104–108
- antiscleroderma, 104–108
- antisperm, 108–110
- antistreptolysin O, 110–111
- antithyroglobulin/antithyroid peroxidase, 112–113
- cardiolipin, 113–115
- gliadin, 115–117
- hepatitis A, 693–695
- hepatitis B, 695–698
- hepatitis C, 698–700
- hepatitis D, 700
- Jo-1, 104–108
- parvovirus, 517–519
- platelet, 948–949
- rubella, 1053–1054
- rubeola, 1053–1054
- Toxoplasma*, 1104
- varicella, 1205–1207
- Antibody screen, 459–460
- Anticardiolipin antibody (ACA), 113–115
- Anticromerem antibody, 104–108
- Anticholinergics
 - electromyography and, 566
 - sphincter muscle electromyography and, 568–570
- Anticoagulant therapy
 - aPTT and, 926–929
 - cholinesterase enzyme and, 1031
 - goal of, 1007
 - protein C and, 999–1001
- Anticonvulsant drugs, 117–121
 - effect on EEG, 563
 - toxicity of, 261–263
- Anti-cyclic citrullinated peptide antibody, 96–98
- Anti-D antibody, 233
- Antideoxyribonuclease-B, streptococcal, 122–124
- Antidepressant drugs, 124–128
- Antidiuretic hormone (ADH), 128–130
 - chloride values and, 308–310
 - magnesium level and, 823–824, 825–828
 - sodium levels and, 1065–1067
 - syndrome of inappropriate secretion of, 129–130
 - osmotic concentration and, 900–902
- Anti-DNA antibody, 104–108
- Anti-ds DNA, 104–108
- Antiextractable nuclear antigen, 104–108
- Anti-GBM, 99–100
- Antigen/antibody, antiextractable nuclear, 104–108
- Antiglobulin testing
 - direct, 457–458
 - indirect, 459–460
- Anti-glomerular basement membrane antibody, 99–100
- Antimanic drugs, 131–134
- Antimetabolite therapy, 389–391
- Antimicrobial removal device (ARD), 498
- Antimicrobial therapy, 500–501
- Antimitochondrial and antismooth muscle antibody, 100–102
- Antimitochondrial/antismooth muscle antibody, 100–102
- Antineoplastic drugs, 400–403
- Antineutrophilic cytoplasmic antibody, 102–104
- Antinuclear antibody (ANA), 104–108
- Antiphospholipid syndrome, 106–108, 113–115
- Antiplatelet antibody, 948
- Antiplatelet therapy, 539
- Antipsychotic drugs, 131–134
- Antipyretic drugs, 54–57
- Anti-ribonucleoprotein, 104–108
- Anti-Scl 70, 106–108
- Antiscleroderma antibody, 104–108
- Antismooth muscle antibody (ASMA), 100–102
- Antisperm antibody, 108–110
- Antistreptolysin O antibody, 110–111
- Antithrombin antibody, 811
- Antithrombin III (AT-III), 134–136
- Antithyroglobulin antibody, 112–113
- Antithyroid peroxidase antibody, 112–113
- Antrum syndrome, retained, 639–642
- Anuria, quinidine toxicity and, 86–92
- Anus, 985–988
- Anxiety
 - blood gas analysis in, 227–232
 - carbon dioxide levels in, 278–279
 - effect on EKG, 560
 - exercise stress test and, 595–597
 - FDG-PET scan imaging and, 599
 - RBC count in, 384–388
- Anxiolytic, 563
- Aortic aneurysm, 587
 - abdominal CT of, 404–407
 - CT angiography of, 408–412
 - MRI for, 833–835, 843–846
 - splenic CT of, 450–453
 - thoracic CT for, 454–456
- Aortic atherosclerosis, 70–73
- Aortic coarctation, 844–846
- Aortic dissection
 - coronary angiography of, 71–73
 - MRA for, 829
 - MRI for, 844–846
 - transesophageal echocardiography of, 555–557
- Aortic lymph node, ultrasonography of, 1150–1152

- Aortic valve abnormality, 551–554
- Aortitis, 70–73
- Aortoduodenal fistula, 651–654
- Aplasia, 1020
- Aplastic anemia
 - bone marrow biopsy for, 174–177
 - eosinophil count in, 573–575
 - hemoglobin electrophoresis for, 689–691
 - iron level in, 761
 - LAP levels in, 795–797
 - MRI for, 848–850
 - platelet count in, 380–382
 - RBC morphology in, 393–396
 - reticulocyte count for, 1043–1044
 - T-cell enumeration for, 292–293
 - WBC and differential in, 400–403
- Aplastic crisis, parvovirus B19 and, 929–931
- Apnea
 - ECG and, 557–561
 - pulse oximetry and, 1018–1020
- Apoprotein A and B, 140–143
- Appendectomy, laparoscopic, 782–785
- Appendicitis
 - abdominal CT of, 404–407
 - abdominal laparoscopy for, 782–785
 - barium enema for, 157–159
 - ultrasonography for, 1156–1158
 - WBC and differential in, 399–403
- Appendix, 1155–1158
- Appetite, anticonvulsant toxicity and, 119–121
- aPTT (activated partial thromboplastin time), 811, 925–929
- Aqueous humor, of eye, 752–755
- ARD (antimicrobial removal device), 498
- ARDS (acute respiratory distress syndrome), A/a gradient and a/A ratio in, 30
- Areflexia, magnesium and, 823
- Areola, scaly skin of, 1074
- Arginine, 39–41
- Argonz-Del Castillo syndrome, 991–993
- Arm
 - venipuncture of, 1255
 - x-ray of, 1027–1029
- Arrhythmia(s)
 - abdominal laparoscopy and, 783
 - aspartate aminotransferase levels in, 150–152
 - drugs for, 86–92
 - ECG for, 558
 - effect on echocardiography, 552, 556
 - electrocardiogram for, 559–561
 - gynecologic laparoscopy and, 786
 - Holter monitor for, 707–709
 - intravenous pyelography and, 756
 - proctosigmoidoscopy and, 986
 - stereotactic biopsy and, 1075
 - vertebroplasty and, 1212
- ART (automated reagin testing), 1081
- Arterial aneurysm
 - abdominal angiography of, 58–61
 - carotid angiography of, 67–69
- Arterial atherosclerotic obstruction, 950–954
- Arterial blood gases, 221–232, 1015
- Arterial blood oxygen saturation (SPO₂), 1018–1020
- Arterial calcification
 - plethysmography for, 950–954
 - ultrasonography for, 1129–1131
- Arterial embolism, 950–954
- Arterial fistula, 67–69
- Arterial hypoplasia, 74–77
- Arterial infarction, 79–82
- Arterial injury, 1040–1042
- Arterial occlusion
 - fluorescein angiography for, 623–625
 - plethysmography for, 950–954
 - ultrasonography for, 1129–1131
 - visual field test for, 1215–1217
- Arterial plethysmography, 950–954
- Arterial stenosis, 79–82
 - abdominal angiography of, 58–61
 - carotid angiography of, 67–69
 - pulmonary angiography of, 74–77
- Arterial thrombosis
 - cardiolipin antibody in, 114
 - D-dimer in, 539
- Arterial/alveolar oxygen ratio (a/A ratio), 29–32
- Arterial-venous shunt, 30–32
- Arteriography. *See* Angiography
- Arteriosclerosis, 1234–1236
- Arteriovenous fistula, 58–61, 79–82
- Arteriovenous malformation (AVM), 837–839
 - brain CT of, 417–420
 - pulmonary angiography of, 74–77
- Arteriovenous shunt, 623–625
- Arteritis, temporal, ESR and, 577–578
- Artery. *See also specific arteries*
 - Doppler ultrasonography of, 551–554
 - plethysmography of, 950–954
- Arthritis, 1078–1080. *See also* Rheumatoid arthritis
 - arthrogram for, 143–146
 - arthroscopy for, 147–149
 - bacterial, 1078–1080
 - degenerative
 - arthroscopy in, 147–149
 - synovial fluid analysis in, 1078–1080
 - haptoglobin level in, 686–687

- hemophilic, 1078–1080
- MRI for, 848–850
- parvovirus and, 929–931
- psoriatic, 721–722
- radiography of, 1028–1029
- rheumatoid. *See* Rheumatoid arthritis
- synovial fluid analysis and, 1078–1080
- tuberculous, 1078–1080
- white blood cell scan for, 1231–1233
- Arthrocentesis, 1077
- Arthrogram, 143–146
- Arthroscopy, 146–149
- Artificial ventilation, 227–232
- Asbestosis, 1016–1017
- A-scan ultrasonography, 1131–1133
- Ascariasis, 908–909
- Ascaris lumbricoides* infection, 908–909
- Ascites
 - abdominal laparoscopy for, 782–785
 - KUB study for, 771–772
 - MRI for, 855–857
 - peritoneal fluid analysis for, 935–938
 - ultrasonography for, 1155–1158
- Ascites fluid analysis, 935
- Ascorbic acid, 1226
- Aseptic meningitis, 883
- ASMA (antismooth muscle antibody), 100–102
- Asparagine, 39–41
- Aspartate aminotransferase (AST), 149–152
- Aspartic acid, 39–41
- Aspergilloma, 74–77
- Aspiration
 - cyst, breast ultrasonography for, 1142–1144
 - suprapubic
 - for bacteria culture, 513
 - for urinalysis, 1198
 - for urine cytology, 536
- Aspiration biopsy. *See* Fine-needle aspiration biopsy
- Aspiration pneumonia, 530–534
- Aspiration scan, 643–645
- Asplenia, 902–903
- AST (aspartate aminotransferase), 149–152
- Asthma
 - blood gas analysis in, 226–232
 - chest x-ray of, 302–303
 - eosinophil count in, 573–575
 - gastric acid stimulation test and, 640–642
 - immunoglobulin E level in, 734–735
 - immunoglobulin levels in, 27–28
 - lung perfusion scan for, 805–807
 - myocardial perfusion heart scan and, 890
 - plethysmography for, 951–954
 - potassium levels and, 975–978
 - pulmonary function study for, 1016–1017
 - vitamin B₆ and, 1228
 - WBC and differential in, 400–403
- Asthmatic shock, 277–279
- Astigmatism, 1032–1035
- Asymptomatic gluten-sensitive enteropathy, 116–117
- Ataxia-telangiectasia, 734–735, 737–738
- Atelectasis, 30–32
 - blood gas analysis in, 226–232
 - chest x-ray for, 302–303
 - lung perfusion scan for, 805–807
 - lung ventilation scan for, 808–810
 - plethysmography for, 951–954
- Atherectomy, 58, 66. *See* Arterial stenosis
- Atherosclerosis
 - CRP assay for, 470–472
 - renogram for, 1039–1042
 - ultrasonography for, 1126–1128
- AT-III (antithrombin III), 134–136
- Atopic dermatitis, 27–28
- ATP (adenosine triphosphate), 902–903
- Atransferrinemia, 86–92, 1106–1108
- Atresia
 - ultrasonography for, 1136–1139
 - vitamin E and, 1223–1224
- Atrial hypertrophy, 559–561
- Atrial mural thrombus
 - echocardiography for, 551–554
 - transesophageal echocardiography of, 554–557
- Atrial natriuretic peptide (ANP, atrial natriuretic factor, atrial natriuretic hormone), 152–153, 254
- Atrial septal defect, 805
- Atrial tumor
 - echocardiography for, 551–554
 - transesophageal echocardiography of, 554–557
- Atrophic changes, colposcopy of, 353–355
- Atrophy
 - cerebral, 417–420
 - testicular, 1058–1059
- Attention-deficit hyperactivity disorder (ADHD), 126–128
- Audiogram, 156
- Audiometry, 153–156
- Auditory brainstem response (ABR), 590
- Auditory canal, 905–907
- Auditory evoked potential (AEP), 590–594
- Auditory nerve, MRI of, 836

- Auditory nerve lesion, ABR and, 590
 Auditory system, 1237
 Auer rod, 366
 Autoantibody, platelet, 948–949
 Autoimmune disorder
 antithyroglobulin/antithyroid peroxidase antibody in, 112–113
 beta₂-microglobulin levels in, 880–883
 complement protein levels in, 359–360
 Autoimmune hemolysis, 686–687
 Autoimmune hemolytic anemia, 357–360, 457–458
 Autoimmune hepatitis
 antimitochondrial/antismooth muscle antibody in, 101–102
 cryoglobulin detection in, 485–486
 Autoimmune liver disease, 103–104
 Autoimmune thyroiditis, 357–358
 Automated reagin testing (ART), 1081
 Automobile, lead and, 789–791
 Autonomic nervous system dysfunction, 288–290
 Avascular necrosis, 848–850
 AVM. *See* Arteriovenous malformation (AVM)
 Axillary node
 biopsy of, 202–205
 lymphangiogram of, 818–821
 Azidothymidine (zidovudine), 881–883
 Azoospermia, 1057–1059
 Azotemia
 osmotic concentration in, 899–902
 sodium levels and, 1068–1071
 sodium levels in, 1065–1067
 AZT (zidovudine), 881–883
- B**
- B cells (B lymphocytes), 398
Bacillus cereus, 507–509
 Back pain, 1212–1214
 MRI in, 848
 Bacteremia, 498–501
 Bacterial abscess, liver-spleen scan of, 801–803
 Bacterial arthritis, 1078–1080
 Bacterial culture
 from throat or nasopharyngeal swab, 511–514
 of anal/genital, ear, eye, skin, and wounds, 492–497
 of blood, 498–501
 of sputum, 501–506
 of stool, 506–509
 of urine, 511–514, 1197
 Bacterial empyema, 956–958
 Bacterial endocarditis, 1081–1083
 Bacterial infection
 albumin/globulin ratio, 16–18
 complement protein levels in, 357–358
 CRP assay for, 470–472
 culture for, 492–497
 fecal analysis for, 603–604
 platelet count in, 380–382
 stool culture for, 507–509
 synovial fluid analysis and, 1078–1080
 Bacterial meningitis, 295–298
 Bacterial organism, 677–679
 Bacterial overgrowth
 D-xylose tolerance test for, 547–550
 oxalate levels in, 910–912
 vitamin B₁₂ and, 1218–1219
 Bacterial pericarditis, 932–934
 Bacterial peritonitis, 936–938
 Bacterial pneumonia
 bacterial culture for, 500–501
 cause of, 502
 Bacterial vaginosis, 915
 Bacteriological sputum testing, 1119
Bacteroides, 494–497
 BAEP (brainstem auditory evoked potential), 590
 BAER (brainstem auditory evoked response), 590
 Baker's cyst, 147–149
 Balloon angioplasty, myocardial perfusion scan and, 890
 Balloon pump, intra-aortic, 301–303
 Bandemia, 398
 BAO (basal acid output), 639–642
 Barbiturate
 abuse of, 544–547
 effect on ECG, 560
 Bard BTA, 218–219
 Barium
 abdominal laparoscopy and, 783
 esophagogastroduodenoscopy and, 587
 fecal fat and, 607
 gastric emptying scan and, 643
 gastrointestinal blood loss scan, 651
 gynecologic laparoscopy and, 786
 lymphangiography and, 819
 proctosigmoidoscopy and, 986
 radiography and, 1028
 retrograde ureteropyelography and, 1046
 stool analysis and, 908
 ultrasonography and, 1137, 1140, 1146, 1150, 1164
 uterine fibroid embolization and, 1200

- vertebroplasty and, 1212
- white blood cell scan and, 1231
- Barium enema, 157–159
- Barium sulfate, 1171
- Barium swallow, 160–162
- Bartonella henselae*, 577–578
- Bart's hemoglobin, 690
- Barter's syndrome
 - aldosterone levels in, 20–22
 - magnesium level and, 825–828
 - renin value in, 1036–1039
- Basal acid output (BAO), 639–642
- Basal cell carcinoma, 212–214
- Basophil, 733
- Basophil cell, 398–399
- Basophilic leukemia, 639–642
- Basophilic stippling, 392, 394
- Battery, lead in, 789–791
- BE (barium enema), 157–159
- Beckwith-Wiedemann syndrome, 334
- Bell's palsy, 566–567
- Bence Jones screening test, 731
- Benign meningioma, 837–839
- Benign prostatic hypertrophy (BPH)
 - cystoscopy in, 523–526
 - PSA levels and, 994–995
 - ultrasonography for, 1159–1160
- Benign tumor
 - colonoscopy for, 347–350
 - esophagogastroduodenoscopy for, 586–589
 - liver and spleen scan for, 801–803
 - thyroid scan for, 1090–1092
 - ultrasonography for, 1162–1163
- Benzene toxicity, 960–962
- Benzodiazepine abuse, 544–547
- Beriberi, 1227
 - electromyography for, 566–567
- Bernard-Soulier syndrome
 - bleeding time in, 220
 - platelet count in, 380–382
- Bernstein test, 582–583, 585
- Berylliosis, 260–263
- Beta cell failure, 745–747
- Beta cell transplant, 468–469
- Beta-alanine, 39–41
- Beta-chain substitution, 690
- Beta-globulin, 996–998
- Beta-HCG, 714–717
- Beta-hemolytic streptococcus
 - bacterial culture for, 494–497
 - throat/nasopharyngeal culture for, 509–511
- Beta-hydroxybutyrate, 768
- Beta₂-microglobulin, 878–883
- Beta-subunit-HCG, 714–717
- Bethesda system, 915–916
- Bicarbonate, 223, 224
 - in acidosis, 225
 - in alkalosis, 225
- Biclonal gammopathy, 731
- Bicornate uterus, 728–730
- Bilateral adrenal hyperplasia, 63–65
- Bile duct obstruction, common
 - amylase levels in, 52–53
 - bilirubin levels in, 164–166
 - percutaneous transhepatic cholangiography for, 315–318
- Bile leak, 701–704
- Bile salt deficiency, 606–608
- Biliary atresia
 - alkaline phosphatase levels in, 24–26
 - hepatobiliary scan for, 701–704
 - vitamin E and, 1223–1224
- Biliary cirrhosis
 - antineutrophilic cytoplasmic antibodies in, 103–104
 - ceruloplasmin levels in, 299–300
 - copper levels in, 462–463
 - HDL level in, 326–329
 - osteocalcin levels and, 904–905
- Biliary duct obstruction, common, 1148–1149
- Biliary enteric bypass patency, hepatobiliary scan and, 701–704
- Biliary fistula, 701–704
- Biliary leak, 701–704
- Biliary obstruction
 - haptoglobin level in, 686–687
 - prothrombin time and, 1008–1011
- Biliary sclerosis, 315–318
- Biliary tract, 412–416, 1147–1149
- Biliary tract disease, 910–912
- Biliary tract obstruction
 - alanine aminotransferase levels in, 13–15
 - alkaline phosphatase levels in, 24–26
 - aspartate aminotransferase levels in, 150–152
 - bilirubin levels in, 164–166
- Bilirubin, 162–166
 - amniotic fluid analysis for, 47–51
 - hepatobiliary scan and, 702
 - protoporphyrin and, 575
 - transcutaneous measurement of, 163
 - urine, 1194, 1197
- Bilirubin fraction, 162–166
- Bing test, 1122–1124
- Binocularity, 591–594
- Biophysical profile (BPP), 1134–1139
- Biopsy
 - aspiration. *See* Fine-needle aspiration biopsy
 - bladder, 166–169
 - bone, 170–172
 - bone marrow, 173–177

- Biopsy (*continued*)
- breast, 177–181
 - cervical tissue, 182–185
 - chorionic villus, 185–188
 - colonoscopy and, 426
 - cone, 182–185
 - core, 1074, 1142
 - curettage, 212–214
 - excision, 212–214
 - fine-needle aspiration. *See* Fine-needle aspiration biopsy
 - intestinal, 188–190
 - kidney, 191–194
 - liver, 194–197
 - lung, 197–201
 - lymph node, 202–205
 - muscle, 205–208
 - needle. *See* Fine-needle aspiration biopsy; Needle biopsy
 - open. *See* Open biopsy
 - prostate, 208–211
 - punch, 182, 212
 - shaving, 212–214
 - skin, 212–214
 - stereotactic, 1074–1077
 - thyroid, 215–217
 - vacuum-assisted, 1074
- Biopsy specimen, 677–679
- Bipolar disease
- anticonvulsants for, 119–121
 - antidepressants for, 126–128
- Birth defects
- alcohol abuse and, 544–547
 - chromosome analysis for, 333–336
- Birth weight
- alpha₂-fetoprotein and, 613–617
 - biophysical profile and, 1134–1139
- Bismuth, 1175
- Bitter taste, GER and, 643–645
- Black feces, analysis of, 602–602
- Bladder
- cystometry of, 520–523
 - cystoscopy of, 523–526
 - intravenous pyelography of, 755–758
 - ultrasonography of, 1139–1141
 - voiding cystourethrography of, 526–529
- Bladder biopsy, 166–169
- Bladder calculi
- cystoscopy for, 524–526
 - pelvic CT of, 433–437
- Bladder cancer. *See also* Bladder tumor markers for, 218–220
- skeletal muscle CK-MM and, 474–475
 - urinary calcium levels in, 268–271
- Bladder distention, 771–772
- Bladder diverticulum, 1140–1141
- Bladder fullness, 521
- Bladder function, urodynamic testing of, 520–523
- Bladder injury, voiding cystourethrography in, 526–529
- Bladder paralysis, 521
- Bladder perforation/rupture, 936–938
- Bladder stones
- cystoscopy for, 524–526
 - pelvic CT of, 433–437
- Bladder trauma
- KUB study for, 771–772
 - voiding cystourethrography for, 527–529
- Bladder tumor. *See also* Bladder cancer
- intravenous pyelography for, 756–758
 - ultrasonography for, 1156–1158
 - voiding cystourethrography for, 527–529
- Bladder tumor antigen (BTA), 218
- Blastocystis hominis* infection, 908–909
- Blastomyces*, 198–201
- Blastomycosis, 250–253
- Bleach, urine drug screen and, 546
- Bleb, pulmonary angiography of, 74–77
- Bleeding. *See* Hemorrhage
- Bleeding disorders
- abdominal laparoscopy and, 783
 - aPTT in, 926–929
 - CBC and, 368
 - cystoscopy and, 524
 - fibrin degradation product and, 618–619
 - Hgb and, 374
 - myocardial perfusion heart scan and, 890
 - natural products affecting, 1275
 - proctosigmoidoscopy and, 986
 - prothrombin time and, 1008–1011
 - radiofrequency ablation and, 1025
 - RBC count and, 384
 - RBC indices and, 389
 - RBC morphology and, 393
 - upper GI, 586–589
 - venogram and, 1208
 - vertebroplasty and, 1212
 - vitamin K and, 1225–1226
 - voiding cystourethrography and, 527
 - WBC count and, 399
- Bleeding time, 220
- Blepharitis, 1062–1064
- Blepharochalasis, 1215–1217
- Blighted ovum, ultrasonography of, 1136
- Blind loop syndrome, 626–628
- Blinking, Schirmer tear test and, 1055–1056
- Blood clot
- cystoscopy for, 523–526

- MRI for, 855–857
 proctosigmoidoscopy and, 986
 retrograde ureteropyelography for, 1045–1048
- Blood clotting, 825. *See also* Coagulation entries
- Blood flow
 decreased, PET scan for, 967–970
 echocardiography of heart, 551–554
 myocardial perfusion scan for, 888–889
 transesophageal echocardiography of, 555–557
- Blood gas analysis, 221–232
- Blood groups and antibodies, 233–237
- Blood loss. *See also* Bleeding disorders; Hemorrhage
 anemia due to, platelet count in, 379–382
 bone marrow biopsy for, 174–177
 gastrointestinal, scan for, 651–654
 glycosylated hemoglobin A_{1c} and, 673–674
 hematocrit in, 369–372
 hemoglobin in, 374
 iron level with, 762–764
 reticulocyte count for, 1043–1044
- Blood pool imaging, 237–241
- Blood specimen
 collection equipment, 1257
 collection procedure for, 1257–1260
 order of draw, 1260–1261
 patient preparation for, 1251–1253
 site selection for, 1253–1257
- Blood sugar, 657
- Blood supply loss, 474–475
- Blood test, 1119–1121
- Blood transfusion. *See* Transfusion
- Blood typing, 233–237
- Blood urea nitrogen (BUN), 1177–1180
- Blood urea nitrogen (BUN)/creatinine ratio, 476, 1177–1180
- Blood vessel(s)
 anticardiolipin antibody in, 114
 CT of, 408–412
 lower extremity ultrasonography of, 1169
 MRA of, 828–831
- Bloodborne pathogens standard, 1289–1292
- Blurred vision, 1215–1217
- BNP (brain natriuretic peptide, B-type natriuretic peptide), 254–255
- Body fluid
 collection of, 1263
 fungal culture of, 514–516
 Gram stain of, 677–679
- Body plethysmography, 950–954, 1015
- Bone
 ALP in, 24
 biopsy of, 170–172
 MRI of, 847–850
 phosphorus in, 939, 942
 radiography of, 1027–1029
 radionuclide scan of, 245–248
 zinc in, 1234
- Bone cancer
 calcium values in, 260–263
 ceruloplasmin levels in, 299–300
 urinary calcium levels in, 268–271
- Bone conduction testing, 156
- Bone degeneration, 1028–1029
- Bone disease
 ALP in, 24
 chest x-ray in, 301
 osteocalcin and, 903–905
 scan for, 245–248
 urine calcium and, 268, 269
 vitamin D and, 1220
- Bone marrow
 erythropoietin and, 580
 fungal culture of, 514–516
 iron storage in, 764–765
- Bone marrow biopsy, 173–177
- Bone marrow depression, 400–403
 WBC and differential in, 400–403
- Bone marrow disease, MRI for, 848–850
- Bone marrow failure
 eosinophil count and, 573–575
 RBC count in, 384–388
 WBC and differential in, 400–403
- Bone marrow hyperplasia, 369–372
- Bone marrow transplant, 380, 1043–1044
- Bone metabolism, osteocalcin and, 903–905
- Bone metastasis, 939–942
- Bone mineral densitometry (BMD), 242–245
- Bone necrosis, 245–248
- Bone neoplasm, 269–271
- Bone radiography, 1027–1029
- Bone scan, 245–248
- Bone spur, 1028–1029
- Bordetella*, 509–511
- Borrelia burgdorferi*, 816
- Botulism, 507–509
- Bowel. *See* Colon entries; Intestinal entries; Small bowel entries
- BPH (benign prostatic hypertrophy)
 cystoscopy in, 523–526
 PSA levels and, 994–995
 ultrasonography for, 1159–1160
- BPP (biophysical profile), 1134–1139
- BPP ultrasonography, 1134–1139
- Bradyarrhythmia, Holter monitor and, 707–709

- Bradycardia
 electrocardiogram for, 559–561
 exercise stress test for, 595–597
 heroin and, 546
 potassium levels and, 976–978
- Brain. *See also* Cerebral *entries*
 acetylcholinesterase in, 1030
 computed tomography of, 416–420
 electroencephalography of, 562–564
 evoked potentials and, 590–594
 FDG-PET scan of, 598–601
 MRI of, 836–839
 PET scan of, 962–966
- Brain CK-BB, 473–474
- Brain death, 562–564
- Brain infarct. *See* Cerebral infarction
- Brain injury, 591–594
- Brain ischemia, 409–412
- Brain natriuretic peptide (BNP), 254–255
- Brain trauma, 599–601
- Brain tumor
 antidiuretic hormone and, 129–130
 carbon dioxide levels in, 277–279
 EEG determining, 563–564
 visual field test for, 1215–1217
- Brainstem auditory evoked potential (BAEP), 590
- Brainstem auditory evoked response (BAER), 590
- Brainstem tumor, 591–594
- Branched-chain ketonuria, 767–770
- BRCA1, 840
- BRCA2, 840
- Breast
 FDG-PET scan of, 598–601
 mammography of, 861–864
 MRI of, 839–843
 ultrasonography for, 1142–1144
- Breast abscess, 1142–1144
 mammogram of, 861–864
 MRI of, 839–843
- Breast biopsy, 177–181
- Breast cancer
 alkaline phosphatase levels in, 24–26
 beta₂-microglobulin levels in, 880–883
 biopsy in, 177–181, 1074
 calcitonin stimulation test for, 257–259
 cancer antigen levels in, 284, 285
 DNA ploidy in, 177, 178
 ER assays in, 177, 178
 FDG-PET scan for, 599–601
 ferritin level in, 609–610
 FISH technique for chromosome abnormalities in, 177
 HER-2/neu oncoprotein in, 177, 178
 human chorionic gonadotropin level in, 716–717
 Ki67 in, 177, 178
 markers for, 177, 178
 P53 in, 177, 178
 PCNA in, 177, 178
 PR assays in, 177, 178
 receptor assays in, 177, 178
 SPF in, 177, 178
 stereotactic biopsy for, 1074
 ultrasonography for, 1143–1147
 urinary calcium levels in, 268–271
- Breast cancer gene, 840
- Breast cyst
 mammogram of, 861–864
 MRI of, 839–843
 ultrasonography of, 1142–1144
- Breast disease
 CEA and, 283
 mammogram of, 861–864
- Breast hematoma, mammogram of, 861–864
- Breast implant
 mammography and, 863
 MRI and, 840
 rupture of, 840
- Breast pain, mammogram in, 861
- Breast self-examination, 862
- Breastfeeding, 991–993
- Breath test, 1175–1177
- Breech position (of fetus), 1136–1139
- Bronchial diverticulum, 250
- Bronchial provocation, 1015
- Bronchial stenosis, 250–253
- Bronchial washing, 514–516
- Bronchiectasis
 mycobacteria culture/smear for, 488
 pulmonary angiography of, 74–77
 pulmonary function study for, 1016–1017
- Bronchitis
 angiotensin-converting enzyme in, 82–83
 blood gas analysis in, 226–232
 carbon dioxide levels in, 277–279
 chest x-ray for, 302–303
 lung perfusion scan for, 805–807
 lung ventilation scan for, 808–810
 plethysmography for, 951–954
 pulmonary function study for, 1016–1017
 viral culture for, 517–519
- Bronchoconstriction, 226–232
- Bronchogenic carcinoma. *See also* Lung cancer
 lung ventilation scan for, 808–810
 mediastinoscopy for, 868–871
- Bronchopulmonary aspergillosis, 734–735
- Bronchoscopy, 249–253, 532
- Bronchospasm, 30–32

- Bronchus, oat cell tumor of, 724–726
 Bruise, vitamin K and, 1225
 BTA (bladder tumor antigen), 218
 B-type natriuretic peptide (BNP), 254–255
 Budd-Chiari syndrome, liver-spleen scan in, 801–803
 Bulimia nervosa, 126–128
 Bullae, pulmonary angiography of, 74–77
 Bullet, lead in, 789–791
 Bullous keratopathy, 913–914
 BUN (blood urea nitrogen), 1177–1180
 BUN/creatinine ratio, 476, 1177–1180
 Bundle branch block
 electrocardiogram for, 559–561
 myocardial perfusion heart scan and, 890
 Burkitt's lymphoma, 260–263
 infectious mononucleosis and, 742–744
 Burn(s)
 alanine aminotransferase levels in, 13–15
 albumin/globulin ratio, 16–18
 amino acid levels in, blood test for, 37–38
 chloride values in, 308–310
 complement protein levels in, 359–360
 copper levels in, 462–463
 glucagon level in, 655–657
 haptoglobin level in, 686–687
 hematocrit in, 368–372
 hemoglobin in, 374–378
 hemosiderin levels in, 692–693
 immunoglobulin E level in, 737–738
 ionized calcium values in, 265–267
 LDLC level in, 327–329
 phosphorus levels in, 940–942
 platelet count in, 380–382
 potassium levels and, 975–978
 protein level in, 996–998
 sodium levels in, 1065–1067
 total cholesterol level in, 331–333
 WBC and differential in, 400–403
 zinc level in, 1235–1236
 Burnett's syndrome, 261–263
 Burr cell, 363, 392
 Bypass graft
 MRA of, 836–839
 MRI of, 843–846
 myocardial perfusion scan for, 890
 CA 19–9, 282–284
 CA 27.29, 282–284
 CA 125, 282–284
 Cabot rings, 364, 392
 CAD. *See* Coronary artery disease (CAD)
 Cadmium poisoning, 880–883
 Caffeine
 effect on EEG, 563
 FDG-PET scan imaging and, 599
 PET scan and, 964, 967, 971
 semen analysis and, 1058
 CAH. *See* Congenital adrenal hyperplasia (CAH)
 Calcification(s)
 KUB study for, 770
 mammography of, 862
 myocardial infarction scan and, 886
 plethysmography and, 950
 ultrasonography and, 1129, 1159, 1164
 x-ray of, 1028
 Calcitonin, 256–259
 Calcitonin stimulation test, 256–259
 Calcium
 blood, 259–263
 ionized, 264–267
 phosphorus and, 939
 urine, 267–271
 vitamin D and, 1220
 Calcium and pentagastrin stimulation, 256–259
 Calcium channel blocker, stress testing and, 595–597
 Calcium homeostasis, 920–922
 Calcium imbalance, 595–597
 Calcium oxalate crystal, 911, 1196
 Calcium phosphate crystals, 1078–1080
 Calculus
 bladder
 cystoscopy for, 524–526
 pelvic CT of, 433–437
 blood creatinine clearance test and, 477–479
 CT for, 433–437, 442–445
 cystoscopy for, 524–526
 gallbladder. *See* Cholelithiasis
 pancreatic, 852–854
 renal. *See* Renal calculi
 retrograde ureteropyelography for, 1045–1048
 ultrasonography for, 1153–1154
 ureteral, 756–758
 urethral, 1183–1185
 urine creatinine clearance test and, 482–484
 Calculus panel, 271–272
Campylobacter, 506–509, 507–509
 c-ANCA (cytoplasmic antineutrophil cytoplasmic antibody), 102–104

C

- C-14 breath test, 1175–1177
 C3 complement, 356–358
 C4 complement, 356–358
 CA 15–3, 282–284

- Cancer. *See* Malignancy; *site- and type-specific entries*
- Cancer antigens, 282–285
- Cancer screening, proctosigmoidoscopy and, 985–988
- Cancer staging
 laparoscopic, 782–785
 lymph node biopsy for, 202–205
 lymphangiogram and, 818–821
 mediastinoscopy for, 868–871
 MRI in, 832, 851, 855
 prostatic ultrasonography in, 1158–1160
 PSA and, 933–995
- Candida albicans*, 501, 515–516
- Candida* spp., 917
- Cannabinoid, 544–547
- Capillaritis, 103–104
- Capillary blood gas, 221–232
- Capillary function, bleeding time, 220
- Capillary puncture, 1253–1254
- Capsule endoscopy, 273–276
- Carbamate insecticide, 1030
- Carbamazepine, 117–121, 543
- Carbohydrate deficiency, ketones and, 767–770
- Carbohydrate diet
 apolipoprotein A and, 141–143
 blood gas analysis in, 227–232
 electrocardiogram and, 560
 urine urea nitrogen level and, 1181–1182
- Carbohydrate metabolism, 776–779
- Carbon dioxide, 276–279
 partial pressure of, in blood, 222, 223
 in acidosis, 225
 in alkalosis, 225
- Carbon monoxide poisoning
 blood gas analysis in, 226–232
 methemoglobin and, 874
 pulse oximetry and, 1018
- Carbon tetrachloride toxicity, 960–962
- Carbonic acid, 224
- Carboxyhemoglobin, 280–282
- Carcinoembryonic antigen (CEA), 282–285
- Carcinoid syndrome
 ACTH levels in, 10
 amino acid levels in, blood test for, 37–38
 calcitonin stimulation test for, 257–259
 fecal fat and, 606–608
 vitamin A and, 1228
 vitamin B₁ and, 1228
- Carcinoid tumor, 724–726
- Carcinoma
 aldolase levels in, 18–19
 alpha₁-antitrypsin levels in, 138–139
 amylase levels in, 52–53
 antithrombin III levels in, 135–136
 breast biopsy for, 179–181
 cancer antigen levels in, 284–285
 colposcopy for, 353–355
 cortisol levels in, 465–467
 erythrocyte sedimentation rate and, 577–578
 hemoglobin in, 374–378
 immunoglobulin E level in, 734–735
 iron level in, 762–764
 kidney CT for, 442–445
 mycobacteria culture/smear for, 488
 pancreatic CT of, 429–433
 platelet count in, 379–382
 RBC morphology in, 393–396
 thyroglobulin values in, 1087–1088
 urinary calcium levels in, 268–271
 vitamin B₁₂ and, 1218–1219
 WBC and differential in, 400–403
- Carcinoma in situ, 182–185
- Carcinomatosis
 MRI for, 855–857
 pseudocholinesterase level in, 1011–1012
- Cardiac. *See also* Heart *entries*
- Cardiac abnormality, 1136–1139
- Cardiac allograft rejection, 254–255
- Cardiac arrest, magnesium and, 823
- Cardiac arrhythmias. *See* Arrhythmia(s)
- Cardiac blood pool scan, 238–241
- Cardiac chamber, 844–846
- Cardiac chamber disorder
 myocardial perfusion heart scan for, 890–893
 PET scan for, 967–970
- Cardiac CK-MB, 473–474
- Cardiac cycle, 559
- Cardiac disease. *See* Heart disease *and specific conditions*, e.g., Coronary artery disease (CAD)
- Cardiac disorder(s)
 blood gas analysis in, 226–232
 carbon dioxide levels in, 277–279
 echocardiography for, 551–554
 proctosigmoidoscopy and, 986
- Cardiac failure. *See also* Congestive heart failure
 aldosterone levels in, 20–22
 lactic acid levels and, 777–779
 natriuretic peptides in, 254–255
 protein level in, 996–998
- Cardiac filling pressure, elevated, ANP in, 153
- Cardiac function, 594–597
- Cardiac glycosides, 595–597

- Cardiac hypertrophy
 blood pool imaging for, 239–241
 myocardial perfusion heart scan for, 888–893
- Cardiac inflammation, 254–255
- Cardiac ischemia, 239–241
- Cardiac markers, 1116
- Cardiac muscle, 558
- Cardiac muscle dysfunction, 599–601
- Cardiac muscle ischemia, 843–846
- Cardiac neoplasm
 echocardiography for, 551–554
 myocardial infarction scan and, 886
- Cardiac output, decreased
 exercise stress test for, 595–597
 plethysmography and, 951
- Cardiac pacemaker
 MRA and, 829
 MRI and, 833, 837, 841, 844, 848, 852, 855, 859
- Cardiac plaque CT, 421
- Cardiac rehabilitation, exercise stress test and, 594–597
- Cardiac scoring, 421–424
- Cardiac septal defect. *See* Septal defect
- Cardiac surgery, 894–895
- Cardiac trauma, 886
- Cardiac troponin I (cTnI), 1116–1118
- Cardiac troponin T (cTnT), 1116–1118
- Cardiac valve. *See named valve*
- Cardiac volume overload, asymptomatic, 153
- Cardiac wall, echocardiography of, 551–554
- Cardiolipin antibody, 113–115
- Cardiomyopathy
 coronary angiography of, 70–73
 echocardiography for, 551–554
 Holter monitor and, 707–709
 microalbumin and, 877–879
 transesophageal echocardiography of, 555–557
- Cardiopulmonary function, 1018–1020
- Cardiothoracic surgery, 618–619
- Cardiotonic therapy, 890
- Cardiovascular disease
 abdominal laparoscopy and, 783
 chest x-ray and, 301–303
 folate deficiency and, 626
 natural products affecting, 1274
- Cardiovascular system
 diagnostic tests for, 1238
 laboratory and tests for, 1237
- Carnivorous diet, 481–484
- Carnosine, 39–41
- Carotene, 1226
- Carotid angiogram, 66–69
- Carotid angiography, 66–69
- Carotid artery stenosis, 551–554
- Carotid Doppler ultrasonography, 551–554
- Carpal tunnel syndrome
 electromyography for, 566–567
 electroneurography for, 571–572
 vitamin B₆ and, 1228
- Cartilage, torn, 147–149
- Cast(s), 1195, 1196
- Castration, 629–631
- CAT (computed axial tomography). *See* Computed tomography (CT)
- Cat scratch fever
 erythrocyte sedimentation rate and, 577–578
 vitamin D and, 1220–1222
- Catabolism, increased, 16–18
- Cataract
 A-scan ultrasonography for, 1132–1133
 gonioscopy for, 676–677
 nerve fiber analysis and, 896
 pinhole test and, 1032
- Catecholamine
 blood and urine, 286–290
 vanillylmandelic acid and, 1203
- Catheter. *See also* Indwelling catheter
 central venous, 301–303
 Swan-Ganz, 301–303
- Catheterization, urinary
 for bacteria culture, 513
 for urinalysis, 1198
 for urine cytology, 536
- Cation, 974, 979
- Cat's eye syndrome, 334
- Cavernous sinuses, pituitary, CT of, 433–437
- CBC. *See* Complete blood count (CBC)
- C-cell hyperplasia, 257–259
- CDC (Centers for Disease Control)
 standard precautions, 1285–1287
 transmission-based precautions, 1277–1279
- CD4/CD8 enumeration, 291–293
- CEA (carcinoembryonic antigen), 283
- Celiac disease, 261–263
 alkaline phosphatase levels in, 25–26
 capsule endoscopy for, 274–276
 copper levels in, 462–463
 D-xylose tolerance test for, 547–550
 fecal fat and, 606–608
 gliadin antibody in, 116–117
 glucose tolerance test for, 666–669
 5-hydroxyindoleacetic acid level in, 724–726
 intestinal biopsy for, 188–190
 oxalate levels in, 910–912
 urinary calcium levels in, 269–271

- Celiac disease (*continued*)
vitamin D and, 1220–1222
- Cellular dysplasia, 353–355
- Centers for Disease Control (CDC)
standard precautions, 1285–1287
transmission-based precautions,
1277–1279
- Central nervous system (CNS)
drug abuse and, 545
vitamin B₁₂ and, 1217
- Central nervous system disorder
antidiuretic hormone and, 129–130
glucose tolerance test for, 666–669
sodium levels in, 1065–1067
vitamin B₁₂ and, 1218–1219
- Central nervous system tumor
aldolase levels in, 18–19
blood gas analysis in, 227–232
- Central venous catheter, chest x-ray and,
301–303
- Cephalosporium*, 515–516
- Cerebral aneurysm, 837–839
- Cerebral atrophy, 417–420
- Cerebral edema, 417–420
- Cerebral infarction
CK and, 474–475
CT of, 416–420
EEG determining, 563–564
MRI of, 836–839
TG and, 1108–1111
- Cerebral neoplasm. *See* Brain tumor
- Cerebral trauma, 544–547
- Cerebrospinal fluid (CSF)
analysis of, 293–298
FTA-ABS method for, 1081
fungal culture of, 514–516
tau protein in, 32–34
- Cerebrovascular accident (CVA)
aspartate aminotransferase levels in,
150–152
glucose levels in, 658–662
PET scan for, 963–966
visual field test for, 1215–1217
- Cerebrovascular disease, Alzheimer's disease markers in, 32–34
- Certificate of Waiver (COW), 1273
- Ceruloplasmin (Cp), 295–298,
461–463
- Cerumen accumulation, 906–907
- Cervical biopsy, 182–185
- Cervical block, 182–185
- Cervical cancer
cancer antigen levels in, 284–285
colposcopy for, 353–355
viral culture for, 517–519
- Cervical cord lesion, 521
- Cervical dysplasia, 182–185
- Cervical erosion, 353–355
- Cervical intraepithelial neoplasia,
353–355
- Cervical LEEP, 917
- Cervical lymphadenopathy, infectious mononucleosis and, 742–744
- Cervical pathology, 591–594
- Cervical polyp, 182–185
- Cervical smear, 915
- Cervical spine angiography, 66–69
- Cervical spine lymph node, biopsy of,
182–185
- Cervical spondylosis, 446–449
- Cervical vaginal specimen, semen analysis and, 1059
- Cervicography, 353
- Chain of custody protocol, 544–547
- Chain substitution, Hgb electrophoresis,
689–691
- Chalasia
barium swallow for, 160–162
esophageal manometry for, 583
- Chalasis, 1172–1174
- Challenge test
ACTH and, 7–12
cortisol and, 463
- Chancroid
lymph node biopsy for, 202–205
syphilis serology testing for,
1081–1083
- Charcoal. *See* Activated charcoal
- CHD (congenital heart disease), 844–846
- Chédiak-Higashi syndrome, 380–382
- Chemicals, 874–876
- Chemotherapy
abdominal laparoscopy and, 783
bone marrow biopsy during, 174–177
erythropoietin level and, 581
immunofixation electrophoresis and,
731
immunoglobulin level with, 738
proctosigmoidoscopy and, 986
RBC count in, 384–388
RBC morphology in, 393–396
uric acid level in, 1186–1188
- Chest
echocardiography of, 551–554
lung perfusion scan of, 804–807
lung ventilation scan of, 807–810
MRI of, 843–846
myocardial perfusion heart scan of,
888
PET scan of, 966–970
transesophageal echocardiography of,
554–557
- Chest lesion, CT of, 454–456
- Chest mass, 805–807
- Chest pain
abdominal laparoscopy and, 783

- echocardiography for, 551–554
 exercise stress test for, 595–597
 gynecologic laparoscopy and, 786
 vertebroplasty and, 1212
- Chest radiography, 301–303, 1119
 Chest trauma, 1016–1017
 Chest tube, chest x-ray and, 301–303
 Chest wall trauma
 myocardial infarction scan and, 886
 prolactin level in, 991–993
- Chest x-ray, 301–303, 551–554
 Chiari-Frommel syndrome, 991–993
 Chickenpox
 syphilis serology testing for, 1081–1083
 varicella-zoster and, 1205–1207
- Child
 acute iron poisoning, 761
 age-specific communication and, 1266
 amino acid screen in, 39–41
 blood gas analysis in, 221–232
 calcium values in, 259–260
 carbon dioxide measurement in, 276
 complement proteins in, 356
 feminization in, 589–590
 follicle-stimulating hormone level in, 628
 glucose levels in, 657
 growth spurt in, 904–905
 haptoglobin level in, 685
 hearing loss audiometry in, 156
 hypoglycemia in, 745
 intravenous pyelography and, 756
 lymphangiography and, 819
 metanephrine levels in, 871
 protein level in, 996
 radiography of, 1028–1029
 retrograde ureteropyelography and, 1046
 sodium levels in, 1065
 total cholesterol level in, 329–333
 total CK in, 472
 uric acid level in, 1185–1188
 urine urea nitrogen level in, 1181–1182
 vanillylmandelic acid level in, 1203
 vitamin C level in, 1227
 zinc deficiency in, 1234
- Child abuse, 1028–1029
 Chlamydia, 304, 917. *See also Chlamydia trachomatis*
Chlamydia group antibody, 304–306
Chlamydia psittaci, 304
Chlamydia trachomatis, 304–306, 494
 DNA probe assays for, 304, 492
- Chloride
 blood, 306–310
 sweat, 311–314
- Cholangiocarcinoma
 cancer antigen levels in, 284–285
 percutaneous transhepatic cholangiography for, 315–318
- Cholangiography
 percutaneous transhepatic, 314–318
 postoperative, 318–321
- Cholangiopancreatography, endoscopic retrograde, 321–324
- Cholangitis
 bilirubin levels in, 164–166
 ERCP in, 321–324
 MRI for, 833–835
 percutaneous transhepatic cholangiography in, 315–318
- Cholecalciferol, 1220
- Cholecystitis, 1148–1149
 alkaline phosphatase levels in, 24–26
 bilirubin levels in, 164–166
 hepatobiliary scan for, 701–704
 lipase levels in, 797–799
- Choledochal cyst, 701–704
- Cholelithiasis, 575, 1148–1149
 abdominal CT of, 404–407
 hepatobiliary scan for, 701–704
 liver/biliary tract CT of, 412–416
 percutaneous transhepatic cholangiography for, 315–318
- Cholera, 603–604
- Cholescintigraphy. *See* Hepatobiliary scan
- Cholestasis
 apolipoprotein A and, 141–143
 HDL level in, 326–329
 sweat chloride and, 311–314
 total cholesterol level in, 330–333
 vitamin E and, 1223–1224
- Cholestatic drug interaction, 164–166
- Cholesterol
 apolipoprotein A and B, 141–143
 cardiac scoring of, 421–424
 HDL and LDL, 325–329
 total, 329–333
- Cholesterol ester storage disease, 194–197
- Cholinergics
 electromyography and, 566
 sphincter muscle electromyography and, 568–570
- Cholinesterase, red blood cell, 1030–1032
- Chondromalacia
 arthrogram of, 143–146
 arthroscopy of, 147–149
- Chordoma, 438–441
- Chorea, 114
- Choriocarcinoma, 715–717

- Chorioepithelioma, 989–990
- Chorionic gonadotropin, human,
714–717
quad-marker testing and, 613, 715
triple-marker testing and, 613, 614,
715
- Chorionic villus biopsy, 185–188
- Choristoma, 859–861
- Choroidal nevus
fundus photography and, 634–635
visual field test and, 1215–1217
- Chromosome abnormality, 48–51
- Chromosome analysis, blood, 333–336
- Chronic bilateral pyelonephritis, 482–484
- Chronic bronchitis
plethysmography for, 951–954
pulmonary function study for,
1016–1017
- Chronic disease, 1112–1113
- Chronic fatigue syndrome, infectious
mononucleosis and, 742–744
- Chronic glomerulonephritis, 1189
- Chronic granulocytic leukemia,
1218–1219
- Chronic hemolytic anemia, 393–396
- Chronic hepatitis. *See* Hepatitis
- Chronic infection
cryoglobulin detection in, 485–486
transferrin level in, 1106–1108
vitamin A and, 1228
- Chronic inflammation, 795–797
- Chronic inflammatory disease, 384–388
- Chronic interstitial nephritis, 975–978
- Chronic kidney disease (CKD)
creatinine in, 476, 480
vitamin levels and, 1227
- Chronic lymphoblastic leukemia,
795–797
- Chronic lymphocytic leukemia, 485–486
- Chronic myelocytic leukemia, 331–333
- Chronic myelogenous leukemia, 796–797
- Chronic obstructive pulmonary disease
(COPD)
A/a gradient and a/A ratio in, 30
aldosterone levels in, 20–22
alpha₁-antitrypsin levels in, 138–139
blood gas analysis in, 226–232
erythropoietin level in, 581–582
hematocrit in, 369–372
hemoglobin in, 374–378
lung perfusion scan for, 805–807
lung ventilation scan for, 808–810
PET scan for, 967–970
plethysmography for, 951–954
pulmonary function study for,
1015–1017
RBC count in, 384–388
total cholesterol level in, 331–333
transesophageal echocardiography of,
555–557
vitamin B₁₂ and, 1218–1219
- Chronic pulmonary disease
apolipoprotein B and, 141–143
LDLC level in, 327–329
- Chronic renal failure (CRF)
amino acid levels in, urine test for, 40
prealbumin and, 983–984
prolactin level in, 991–993
vitamin B₁₂ and, 1218–1219
- Chronic sinopulmonary disease,
737–738
- Churg-Strauss syndrome, 103–104
- Chylous pleural effusion, 956–958
- Cigarette smoking. *See* Smoking
- Ciliary body, gonioscopy of, 675–677
- Cimetidine, 606
- Cine scanning, 404, 412–413
- Circadian rhythm
luteinizing hormone secretion and,
815
magnesium level and, 826
- Circulating anticoagulant
aPTT in, 927–929
prothrombin time and, 1008–1011
- Circulating C3, 356
- Circulating fibrinogen
aPTT in, 927–929
rouleaux and, 577
- Circulation. *See* Blood flow
- Circulatory overload, transfusion related,
1271
- Cirrhosis, 254–255
abdominal laparoscopy for, 782–785
AFP levels in, 614–617
alanine aminotransferase levels in,
13–15
aldosterone levels in, 20–22
alpha₁-antitrypsin levels in, 138–139
amino acid levels in, urine test for, 40
ammonia levels in, 44–45
antimitochondrial/antismooth muscle
antibody in, 101–102
antithrombin III levels in, 135–136
aspartate aminotransferase levels in,
150–152
bilirubin levels in, 164–166
calcitonin stimulation test for,
257–259
calcium values in, 261–263
cancer antigen levels in, 284–285
copper levels in, 462–463
cryoglobulin detection in, 485–486
estradiol level in, 589–590
GGT levels in, 670–672
glucagon level in, 655–657
HDLc level in, 326–329

- human growth hormone levels in, 683–684
- lactate dehydrogenase levels in, 775–776
- liver and spleen scan for, 801–803
- liver biopsy for, 194–197
- osteocalcin levels and, 904–905
- oxalate levels in, 910–912
- percutaneous transhepatic cholangiography for, 315–318
- peritoneal fluid analysis for, 936–938
- platelet count in, 379–382
- protein level in, 996–998
- protoporphyrin and, 575
- pseudocholinesterase level in, 1011–1012
- renin value in, 1036–1039
- rheumatoid factor and, 1049–1050
- total iron-binding capacity and, 765–766
- triglyceride levels and, 1109–1111
- ultrasonography for, 1148–1149
- vitamin B₁₂ and, 1218–1219
- vitamin E and, 1223–1224
- WBC and differential in, 400–403
- zinc level in, 1235–1236
- Citrulline, 39–41
- CK (creatinine kinase), 472–475
- CKD (chronic kidney disease)
- creatinine in, 476, 480
 - vitamin levels and, 1227
- Claustrophobia
- MRA and, 829
 - MRI and, 837, 841, 844, 848, 852, 856, 859
- Clean-catch specimen. *See also* Urine specimen
- for drug screening, 547
 - for magnesium measurement, 826
 - for microalbumin testing, 878
 - for urinalysis, 1198
 - for urine cytology, 535
 - hemosiderin stain and, 692–693
 - ketones, measuring levels in, 769
 - osmolality and, 901
 - oxalate levels in, 911
 - phosphorus levels and, 944
 - porphyrin levels and, 960–962
 - potassium levels and, 981
- Cleaning, isolation precautions and, 1282
- CLIA (Clinical Laboratory Improvement Amendments), 1273
- Clinical Laboratory Improvement Amendments (CLIA), 1273
- Clomiphene, 542
- Clomiphene induction, progesterone and, 988–990
- Clonorchis sinensis* infection, 908–909
- Closing volume, 1014, 1016
- Clostridium*
- bacterial culture for, 494–497
 - stool culture for, 506–509
- Clostridium botulinum*, 507–509
- Clostridium difficile*, 507–509
- Clot. *See* Blood clot
- Clot removal, venipuncture and, 1256–1257
- Clot retraction test, 336–337
- Clotting factor congenital deficiency, 927–929
- Clotting specimen, 949
- Clue cell, 1195
- CMV. *See* Cytomegalovirus (CMV)
- CNS. *See* Central nervous system (CNS) entries
- Coagulation. *See* Blood clot
- Coagulation defect, 587
- Coagulation factors, 338–341
- deficiency of
 - aPTT in, 927–929
 - vitamin B₁₂ and, 1218–1219
- Coagulopathy
- bleeding time and, 220
 - disseminated intravascular. *See* Disseminated intravascular coagulation (DIC)
- Coarctation, 829–831
- Cobalamin abnormality, 1218–1219
- Cocaine abuse, 544–547, 894–895
- Cocaine dependence, 126–128
- Coccidioides immitis*, 515–516
- Coccidioidomycosis
- bronchoscopy for, 250–253
 - calcium values in, 260–263
 - mediastinoscopy for, 868–871
- Codocyte, 363, 392
- COHb (carboxyhemoglobin), 280–282
- Cold agglutinin titer, 341–343
- Cold hemagglutinin disease, 341–342
- hemosiderin in, 692
 - IgM in, 737
- Cold sensitivity, RAIU and, 1021–1023
- Cold spot, in thyroid scan, 1089–1092
- Colitis
- amebic, 603–604
 - colonoscopy for, 347–350
 - granulomatous, 157–159
 - ulcerative. *See* Ulcerative colitis
 - WBC and differential in, 400–403
- Collagen cross-linked N-telopeptide (NT_x), 344–346
- Collagen disease/disorder, 577–578
- copper levels in, 462–463
 - WBC and differential in, 399–403
- Collateral circulation, 634–635
- Collecting system tumor, 756–758

- Colon. *See also* Colitis
 barium enema of, 157–159
 proctosigmoidoscopy of, 985–988
- Colon cancer. *See also* Colorectal cancer
 alkaline phosphatase levels in, 24–26
 barium enema for, 157–159
 colonoscopy for, 347–350
 human chorionic gonadotropin level
 in, 716–717
- Colon perforation, 157–159
- Colonic polyp
 barium enema and, 157–159
 colonoscopy and, 347–350, 425–429
 fecal analysis and, 605–609
 proctosigmoidoscopy and, 986–988
- Colonography, 425
- Colonoscopy, 346–350, 602
- Color blindness, 351–352
- Color perception test, 351–352
- Colorectal adenoma, 602
- Colorectal cancer. *See also* Colon cancer
 barium enema for, 157–159
 cancer antigen levels in, 284–285
 FDG-PET scan for, 599–601
- Colposcopy, 353–355
- Coma, 545. *See also* Hepatic coma
 acetaminophen intoxication and,
 54–57
 anticonvulsant toxicity and, 261–263
 antidepressants toxicity, 124–128
 antipsychotic toxicity, 131–134
 diabetic, 544–547
 lidocaine toxicity and, 86–92
- Common bile duct dilation
 abdominal CT of, 404–407
 kidney CT for, 442–445
 liver/biliary tract CT of, 412–416
- Common bile duct obstruction
 amylase levels in, 52–53
 hepatobiliary scan for, 701–704
- Common vehicle transmission of
 pathogen, 1278
- Communication, age-specific, 1265–1268
- Compatibility test, 233
- Complement protein
 C3 and C4, 356–358
 total, 359–360
- Complete blood count (CBC), 360–367
 hematocrit, 367–372
 hemoglobin, 372–378
 platelet count, 378–382
 RBC count, 383–388
 RBC indices, 363, 388–391
 RBC morphology and inclusions,
 391–396
 white blood count and differential in,
 396–403
- Compound F, 463
- Compression fracture, vertebroplasty
 and, 1212
- Computed axial tomography (CAT). *See*
 Computed tomography (CT)
- Computed tomography (CT)
 angiography, 408–412
 cardiac scoring, 421–424
 colonoscopy, 425–429
 of abdomen, 403–407
 of biliary tract and liver, 412–416
 of brain, 416–420
 of kidney, 441–445
 of pancreas, 429–433
 of pelvis, 433–437
 of pituitary gland, 437–441
 of spine, 445–449
 of spleen, 449–453
 of thorax, 453–456
 spleen ultrasonography and, 1163
- Computed tomography angiography
 (CTA), 408–412
- Computed transaxial tomography (CTT).
See Computed tomography (CT)
- Conduction defect, Holter monitor and,
 707–709
- Conduction velocity, ENG and, 570–572
- Conductive hearing loss, 1071–1073
- Condylar injury, arthroscopy of,
 146–149
- Condyloma
 colposcopy for, 353–355
 Pap smear and, 917
- Condylomata, 517–519
- Cone biopsy, 182–185
- Confusion
 acetaminophen intoxication and,
 54–57
 antidepressant toxicity and, 124–128
 antipsychotic toxicity and, 131–134
- Congenital adrenal hyperplasia (CAH)
 ACTH levels in, 10
 progesterone testing for, 989–990
 sweat chloride and, 311–314
- Congenital anomaly
 abdominal angiography of, 58–61
 brain CT of, 417–420
 carotid angiography of, 67–69
 coronary angiography of, 70–73
 echocardiography for, 551–554
 electrocardiogram for, 558–561
 renal angiography of, 79–82
 ultrasonography for, 1145–1147
 upper GI series for, 1172–1174
- Congenital atrophy, 1087–1088
- Congenital biliary atresia, 701–704
- Congenital cardiac septal defect, 30–32
- Congenital dyserythropoietic anemia, 683
 PNH and, 685

- Congenital fibrinogen deficiency, 620–622
 Congenital heart block, 106–108
 Congenital heart defect, 226–232
 Congenital heart disease
 ECG in, 558
 echocardiography in, 551
 MRI in, 844
 TEE in, 554, 555
 Congenital infection, 380–382
 Congenital methemoglobinemia, 874–876
 Congenital nephrosis, AFP in, 615
 Congenital nonspherocytic anemia
 G6PD levels in, 663
 pyruvate kinase levels in, 1020
 Congenital porphyria, 960–962
 Congenital renal anomaly, 771–772
 intravenous pyelography for, 756–758
 retrograde ureteropyelography for, 1045–1048
 Congenital urinary tract abnormality, 756–758
 Congenital venous malformation, venography of, 1207–1211
 Congestive heart failure
 albumin/globulin ratio, 16–18
 alkaline phosphatase levels in, 24–26
 aspartate aminotransferase levels in, 150–152
 blood creatinine clearance test and, 477–479
 blood gas analysis in, 226–232
 BNP levels in, 237, 254
 BUN levels in, 1178–1180
 cardiac CK-MB and, 474–475
 chloride values in, 308–310
 echocardiography for, 551–554
 erythrocyte sedimentation rate and, 577–578
 hematocrit in, 369–372
 hemoglobin in, 374–378
 lactate dehydrogenase levels in, 775–776
 osmotic concentration and, 900–902
 potassium levels and, 976–978
 renin value in, 1036–1039
 sodium levels in, 1065–1067
 transesophageal echocardiography of, 555–557
 uric acid level in, 1186–1188
 vitamin B₁₂ and, 1218–1219
 Conjugated/direct bilirubin, 162–166
 Conjunctiva, slit-lamp biomicroscopy of, 1061
 Conjunctivitis
 slit-lamp biomicroscopy for, 1062–1064
 viral culture for, 517–519
 Connective peptide insulin, 467
 Connective tissue disease
 angiotensin-converting enzyme in, 82–83
 antinuclear antibody and, 106–108
 anti-ribonucleoprotein and, 106–108
 bone marrow biopsy for, 174–177
 immunoglobulin E level in, 737–738
 syphilis serology testing for, 1082–1083
 Conn's syndrome, 20–22
 Constrictive pericarditis, MRI of, 844–846
 Contact lens, 1062–1064
 Contact precautions, 1284, 1288–1289
 Contact transmission of pathogen, 1277
 Contraction stress test (CST), 1135
 Contrast medium. *See also specific agent*
 for abdominal angiography, 57–61
 for adrenal angiography, 62–65
 for adrenal scintigraphy, 4–7
 for barium enema, 157–159
 for barium swallow, 160–162
 for carotid angiography, 70–73
 for coronary angiography, 70–73
 for hysterosalpingography, 727–730
 for IVP, 755–758
 for lymphangiography, 818–821
 for pulmonary angiography, 74–77
 for renal angiography, 78–82
 Contusion
 electroneurography and, 570
 renogram for, 1040–1042
 Convulsion
 antipsychotic toxicity, 131–134
 lidocaine toxicity and, 86–92
 magnesium toxicity and, 822–824
 salicylate intoxication and, 227–232
 Coombs' antiglobulin
 direct, 457–458
 indirect, 459–460
 COPD. *See* Chronic obstructive pulmonary disease (COPD)
 Copper, 461–463, 927
 Copper intoxication, 299–300
 Copper oxidase, 295–298
 Copper poisoning, 299–300
 Copper uterine device, use, 462–463
 Coproporphyrin, 959–962
 Cord blood, 657
 Cord blood gas, 221–232
 Core biopsy, breast, 1074–1077
 ultrasonography for, 1142–1144
 Cornea
 pachymetry for, 913–914
 slit-lamp biomicroscopy of, 1061
 Corneal abrasion, 1062–1064
 Corneal arcus, 327–329
 Corneal disorder, 896

- Corneal endothelial disorder, 676–677
- Corneal erosion, 1062–1064
- Corneal infection, 1062–1064
- Corneal rejection, 913–914
- Corneal thickness, 913–914
- Corneal ulcer, 1062–1064
- Coronary angiography, 70–73
- Coronary artery calcification, 886
- Coronary artery disease (CAD)
- angiography in, 70
 - apolipoprotein A and, 141–143
 - apolipoprotein B and, 141–143
 - cardiac scoring for, 421–424
 - echocardiography for, 551–554
 - exercise stress test for, 594–597
 - FDG-PET scan for, 598–601
 - Framingham algorithm and, 1108
 - HDL and LDL levels in, 326–329
 - homocysteine level and, 710–711
 - MRI for, 844–846
 - myocardial perfusion heart scan for, 888–893
 - transesophageal echocardiography of, 554–557
 - zinc level in, 1234–1236
- Coronary artery plaque, CT of, 421–424
- Coronary blood flow
- myocardial infarction scan and, 886
 - myocardial perfusion heart scan and, 888–893
- Coronavirus, viral culture and, 517–519
- Corpus luteum, 988–990
- Corrective lens, refractive errors and, 1032–1035
- Corticosteroids, 825–828
- Corticotropin, 543
- Corticotropin-releasing hormone (CRH)
- stimulation, 7–12, 464–467
- Cortisol
- challenge tests and, 463
 - DHEAS and, 542
 - eosinophil count suppression, 573–575
- Corynebacterium*, 494, 509
- Corynebacterium diphtheriae*, 502, 509
- Cosyntropin, 465
- Cough
- bronchoscopy for, 249–253
 - tuberculin skin test for, 1118–1122
- Cough medicine, 546
- Coumarin, APTT and, 925–929
- Coumarin-induced skin necrosis, protein S and, 1001–1003
- COW (Certificate of Waiver), 1273
- Cow's milk, phosphorus in, 939
- Coxsackievirus, 517–519
- Cp (ceruloplasmin), 295–298, 461–463
- C-peptide, 467–469
- CPK (creatine phosphokinase), 472–475
- Cranial bone, MRI of, 836–839
- Cranial tumor, 963–966
- Craniopharyngioma
- brain CT of, 417–420
 - MRI for, 837–839, 859–861
 - pituitary CT of, 437–441
- C-reactive protein (CRP), 470–472
- Creatine kinase (CK), 472–475
- Creatine phosphokinase (CPK), 472–475
- Creatinine
- blood, 476–479
 - eGFR and, 477
 - homovanillic acid and, 712
 - metanephrine and, 872
 - renogram and, 1040
 - urine, 480–484
 - vanillylmandelic acid and, 1203
- Creatinine clearance test
- blood sample and, 476–479
 - urine sample and, 480–484
- Cretinism, ALP levels in, 23–26
- Creutzfeldt-Jakob disease
- Alzheimer's disease markers and, 32–34
 - PET scan for, 963–966
- CRF. *See* Chronic renal failure (CRF)
- CRH (corticotropin-releasing hormone), 7–12, 464–467
- Cri du chat syndrome, 334
- Crigler-Najjar syndrome, 164–166
- Crohn's disease
- albumin/globulin ratio, 16–18
 - barium enema for, 157–159
 - beta₂-microglobulin levels in, 880–883
 - capsule endoscopy for, 274–276
 - colonoscopy for, 347–350
 - CRP assay for, 470–472
 - erythrocyte sedimentation rate and, 577–578
 - fecal fat and, 606–608
 - folate level in, 626–628
 - immunoglobulin E level in, 737–738
 - magnesium level and, 825–828
 - oxalate levels in, 910–912
 - potassium levels and, 976–978
 - proctosigmoidoscopy for, 985–988
 - protein level in, 996–998
 - vitamin B₁₂ and, 1218–1219
- Croup, 517–519
- CRP (C-reactive protein), 470–472
- Crush injury
- albumin/globulin ratio, 16–18
 - aldolase levels in, 18–19
 - WBC and differential in, 400–403
- Cryoglobulin, 485–486, 738

- Cryoglobulinemia
 complement protein levels in, 357–358, 359–360
 detection of, 485–486
 immunofixation electrophoresis for, 731
- Cryptococcus neoformans*, 515–516
- Cryptorchidism
 infertility and, 109–110
 testosterone and, 1085–1086
 ultrasonography for, 1161–1163
- Cryptosporidiosis, 908–909
- Cryptosporidium parvum* infection, 908–909
- Crystal(s)
 calcium oxalate, 911, 1196
 calcium phosphate, 1078–1080
 cystine, 1196
 hemoglobin C, 364, 392
 leucine, 1196
 tyrosine, 1196
 urine, 1196
- Crystallization, amniotic fluid, 46
- CSF. *See* Cerebrospinal fluid (CSF)
- CST (contraction stress test), 1135
- CT. *See* Computed tomography (CT)
- C-terminal parathyroid hormone, 919–922
- cTNI (cardiac troponin I), 1116–1118
- cTNT (cardiac troponin T), 1116–1118
- Cu. *See* Copper
- Culture
 anal/genital, 492–497
 blood, 498–501, 514–516
 body fluid, 514–516
 bone marrow, 514–516
 ear, 492–497
 eye, 492–497
 fungal, 514–516
 genital, 492–497
 hair, 514–516
 mycobacterial, 487–492
 nail, 515–516
 nasopharyngeal swab, 509–511
 skin, 492–497, 514–516
 sputum, 501–506, 514–516
 stool, 506–509, 514–516
 throat, 509–511
 urine, 511–514
 viral, 517–519
 wound, 492–497
 white blood cell scan for, 1231–1233
- Curettage biopsy, 212–214
- Cushing's disease
 ACTH levels in, 9–10
 albumin/globulin ratio, 16–18
 chloride values in, 307–310
 cortisol levels in, 465–467
 glucagon level in, 655–657
 glucose levels in, 658–662
 glucose tolerance test for, 666–669
 potassium levels and, 976–978, 980–982
 renin value in, 1036–1039
 sodium levels in, 1065–1067
 WBC and differential in, 399–403
- Cushing's syndrome, 254–255
 adrenal scintiscan for, 5–7
 apolipoprotein B and, 141–143
 cortisol levels in, 9–10
 DHEAS and, 542–543
 LDLC level in, 327–329
 WBC and differential in, 400–403
- CVA. *See* Cerebrovascular accident (CVA)
- Cyanocobalamin, 1217–1219
- Cyanosis
 methemoglobin and, 874
 sputum cytology and, 530
- Cyclic antidepressants, 126–128
- Cyclosporine, 739–742, 825–828
- Cyclotron, 970
- Cyst(s)
 abdominal angiography of, 58–61
 abdominal CT of, 404–407
 arthrogram of, 143–146
 arthroscopy of, 147–149
 brain CT of, 417–420
 carotid angiography of, 67–69
 CT angiography of, 409–412
 gynecologic laparoscopy for, 786–788
 hepatobiliary scan for, 701–704
 intravenous pyelography for, 756–758
 kidney CT for, 442–445
 lipase levels in, 797–799
 liver and spleen scan for, 801–803
 liver/biliary tract CT of, 412–416
 mammography for, 862–864
 MRI for, 855–857, 858–861
 pelvic CT of, 433–437
 percutaneous transhepatic cholangiography for, 315–318
 pituitary CT of, 437–441
 progesterone testing for, 989–990
 renogram for, 1040–1042
 skin biopsy for, 212–214
 slit-lamp biomicroscopy for, 1062–1064
 splenic CT of, 450–453
 thoracic CT for, 454–456
 thyroid biopsy for, 215–217
 thyroid scan for, 1090–1092
 ultrasonography for, 1140, 1145, 1156, 1161, 1164
- Cyst aspiration, breast ultrasonography for, 1142–1144
- Cystathionine, 39–41

- Cystic breast disease, 1143–1147
- Cystic fibrosis
- blood gas analysis in, 226–232
 - copper levels in, 462–463
 - fecal analysis for, 603–604
 - fecal fat and, 606–608
 - glucagon level in, 655–657
 - 5-hydroxyindoleacetic acid level in, 724–726
 - sodium levels in, 1065–1067
 - sweat chloride values in, 311–314
 - vitamin A and, 1228
 - vitamin E and, 1223–1224
 - vitamin K and, 1225–1226
- Cystic focal disease, 800–803
- Cystine, 39–41
- Cystine crystals, 1196
- Cystinosis
- amino acid levels in, urine test for, 40
 - blood gas analysis in, 227–232
 - calcium values in, 261–263
- Cystitis
- cystoscopy and, 524
 - ultrasonography for, 1140–1141
 - viral culture for, 518–519
- Cystography, 526–529, 1045
- Cystometry, 520–523
- Cystoscopy, 523–526
- Cystourethrography, voiding, 526–529
- Cytogenic markers, 219
- Cytology
- of sputum, 527
 - of urine, 534–536
- Cytomegalovirus (CMV)
- beta₂-microglobulin levels in, 881–883
 - bronchoscopy for, 250–253
 - IgG and IgM, 537–538
 - Pap smear and, 917
 - urine cytology for, 534–536
 - viral culture for, 518–519
- Cytoplasmic antineutrophil cytoplasmic antibody (c-ANCA), 102–104
- Cytotoxic agents
- abdominal laparoscopy and, 783
 - bone marrow biopsy after, 175–177
 - proctosigmoidoscopy and, 986
- Cytc ThinPrep PapTest, 917
- D**
- D antigen, 233–237
- Dacryocyte, 363, 392
- D-aminolevulinic acid, 41–43
- Danazol, 543
- DAT (direct antiglobulin testing), 457–458
- D-dimer, 539–541
- Deafness/hearing loss
- audiometry in, 153–156
 - otoscopy and, 905–907
 - spondeo speech recognition threshold for, 1071–1073
 - tuning fork test for, 1122–1125
- Death, methemoglobin and, 874–876
- Decubitus ulcer, 493–497
- Deep venous thrombosis (DVT)
- D-dimer in, 539
 - Doppler flow study for, 950
 - ultrasonography for, 1169
 - venogram for, 1207
- Deer tick-borne spirochete, 816
- Degenerative joint disease
- arthroscopy in, 147–149
 - synovial fluid analysis in, 1078–1080
- Degenerative spinal disease, 848–850
- Dehydration
- anion gap for, 84–86
 - blood creatinine clearance test and, 477–479
 - calcium values in, 260–263
 - carbon dioxide levels in, 278–279
 - chloride values in, 307–310
 - hematocrit in, 369–372
 - hemoglobin in, 374–378
 - hemoglobin levels and, 690
 - hysterosalpingography and, 728
 - intravenous pyelography and, 756
 - lymphangiography and, 819
 - magnesium level and, 822–824
 - osmotic concentration and, 900–902
 - potassium levels and, 975–978
 - protein level in, 996–998
 - renogram and, 1040
 - retrograde ureteropyelography and, 1046
 - sodium levels in, 1065–1067
 - transesophageal echocardiography and, 555
 - ultrasonography and, 1137, 1140, 1151, 1156–1158, 1164
 - uterine fibroid embolization and, 1200
 - venogram and, 1208
 - voiding cystourethrography and, 527
- Dehydroepiandrosterone sulfate (DHEAS), 541–543
- Delayed immune-mediated transfusion reaction, 1271
- Delirium tremens
- aspartate aminotransferase levels in, 150–152
 - skeletal muscle CK-MM and, 474–475
- Delta bilirubin, 162–166
- Delta hepatitis, 700
- Delta-globulin, 996–998

- Dementia
- Alzheimer's disease and, 32–34
 - markers for, 32–34
 - evoked brain potentials in, 591–594
 - FDG-PET scan for, 598–601
 - PET scan for, 963–966
- Deoxygenated hemoglobin, 874
- Deoxyribonucleic acid. *See* DNA *entries*
- Depolarization, 558
- Depression, 126–128
 - ACTH levels in, 10
 - antipsychotic/antimanic drugs for, 131–134
 - 5-hydroxyindoleacetic acid level in, 725–726
- Depression of respiratory center, 226–232
- Dermatitis
 - atopic, 27–28
 - eosinophil count in, 573–575
 - exfoliative, 626–628
 - immunoglobulin E level in, 734–735
 - skin biopsy for, 212–214
- Dermatitis herpetiformis, 116–117
- Dermatofibroma, 212–214
- Dermatomyositis
 - aldolase levels in, 18–19
 - aspartate aminotransferase levels in, 150–152
 - complement protein levels in, 357–358
 - electromyography for, 566–567
 - Jo-1 antibody and, 106–108
 - rheumatoid factor and, 1049–1050
 - skeletal muscle CK-MM and, 474–475
- DES (diethylstilbestrol), 353
- Desipramine, 124–128
- DEXA (dual-energy x-ray absorptiometry), 242–245
- Dexamethasone, 543
- Dexamethasone suppression test (DST), 7–12, 464–467
- DHEAS (dehydroepiandrosterone sulfate), 541–543
- DIA (dimeric inhibin-A), 614
- Diabetes insipidus
 - antidiuretic hormone and, 129–130
 - chloride values in, 307–310, 311–314
 - osmolality and, 899–902
- Diabetes mellitus. *See also* Diabetic *entries*
 - ACTH levels in, 10
 - aldosterone levels in, 20–22
 - alkaline phosphatase levels in, 24–26
 - amino acid levels in, blood test for, 37–38
 - apolipoprotein A and, 141–143
 - apolipoprotein B and, 141–143
 - cardiac scoring for, 421–424
 - cause and effects of, 658
 - complement protein levels in, 357–358
 - C-peptide levels in, 468–469
 - fecal fat and, 606–608
 - fluorescein angiography in, 623
 - fructosamine level in, 632–633
 - fundus photography in, 633
 - gastric emptying scan for, 643–645
 - GGT levels in, 670–672
 - glucagon level in, 655–657
 - glucose tolerance test for, 665–669
 - glycated hemoglobin A_{1c} and, 672–674
 - HDLc and LDLc levels in, 326–329
 - hexosaminidase level in, 705–706
 - human growth hormone levels in, 683–684
 - hyperlipoproteinemia and, 799–800
 - insulin antibody and, 748–749
 - insulin levels in, 745–747
 - insulin-dependent (type 1)
 - C-peptide levels in, 468
 - insulin levels in, 745
 - intrinsic factor antibody and, 759
 - insulin-resistant, 745
 - intrinsic factor antibody and, 759–760
 - ketone level in, 767–770
 - lactic acid levels and, 777–779
 - lecithin/sphingomyelin ratio in, 792–795
 - microalbumin and, 877–879
 - non-insulin-dependent (type 2)
 - C-peptide levels in, 468
 - insulin levels in, 745
 - oxalate levels in, 910–912
 - pseudocholinesterase level in, 1011–1012
 - sodium levels and, 1068–1071
 - sodium levels in, 1065–1067
 - total cholesterol level in, 330–333
 - type 1 (insulin-dependent)
 - C-peptide levels in, 468
 - insulin levels in, 745
 - intrinsic factor antibody and, 759
 - type 2 (non-insulin-dependent)
 - C-peptide levels in, 468
 - insulin levels in, 745
 - uric acid level in, 1186–1188
 - urinary calcium levels in, 268–271
 - urine urea nitrogen level in, 1180–1182
 - visual field test for, 1215–1217
 - vitamin B₆ and, 1228
 - vitamin B₁₂ and, 1218–1219
 - zinc level in, 1235–1236

- Diabetic acidosis. *See also* Diabetic ketoacidosis
 catecholamine levels in, 287–290
 magnesium level and, 822–824
- Diabetic coma, 544–547
- Diabetic diet, 661
- Diabetic glomerulosclerosis, 1189
- Diabetic ketoacidosis
 blood gas analysis in, 227–232
 carbon dioxide levels in, 278–279
 chloride values in, 308–310
 osmotic concentration and, 900–902
 phosphorus levels in, 939–942
 potassium levels and, 980–982
 WBC and differential in, 400–403
- Diabetic ketosis
 amino acid levels in, urine test for, 40
 amylase levels in, 52–53
- Diabetic nephropathy
 microalbumin and, 877–879
 protein levels in, 1004–1006
- Diabetic neuropathy
 anticonvulsants for, 119–121
 electromyography in, 566–567
 electroneurography for, 571–572
- Diabetic retinopathy
 fluorescein angiography for, 623
 fundus photography for, 634–635
- Diagnostic tests
 for auditory system, 1237
 for cardiovascular system, 1238
 for endocrine system, 1239
 for gastrointestinal system, 1240
 for genitourinary system, 1241
 for hematopoietic system, 1242
 for hepatobiliary system, 1243–1244
 for immune system, 1245
 for musculoskeletal system, 1246
 for ocular system, 1247
 for reproductive system, 1248
 for respiratory system, 1249
 nursing diagnoses associated with, 1264
 patient preparation for, 1251, 1263
- Dialysis
 potassium levels and, 975–978
 vitamin B₆ and, 1228
- Diaphoresis, acetaminophen intoxication and, 54–57
- Diaphragm, flattened, 302–303
- Diaphragmatic hernia, chest x-ray and, 301–303
- Diaphragmatic inflammation, 801–803
- Diarrhea
 blood gas analysis in, 227–232
 carbon dioxide levels in, 278–279
 chloride loss in, 308
 colonoscopy in, 347–350
 illness with, ketones and, 767–770
 magnesium level and, 823–824
 phosphorus levels in, 940–942
 potassium levels and, 976–978
 radioactive iodine uptake and, 1022
 sodium levels in, 1065–1067
 thyroid scan and, 1090
 vitamin K and, 1225–1226
- Dibucaine number, 1011–1012
- DIC. *See* Disseminated intravascular coagulation (DIC)
- Diet
 fecal analysis and, 603
 gastric acid stimulation test and, 640–642
 hepatobiliary scan and, 702
 5-hydroxyindoleacetic acid level and, 725
 parathyroid scan and, 923
 potassium levels and, 975–978
 radioactive iodine uptake and, 1022
 renin value and, 1037
 thyroid scan and, 1090
 urinalysis and, 1196
 urine urea nitrogen level and, 1181–1182
 vitamin B₁₂ and, 1218–1219
 vitamin levels and, 1229
- Dietary protein, urea nitrogen and, 1180–1182
- Dietary purine, 1186–1188, 1189–1191
- Diethylstilbestrol (DES), 353
- Differentiated thyroid cancer, 1087–1088
- Diffusing capacity, 1012–1017
- Diffusing capacity of lungs (DCOL), 1015–1017
- DiGeorge syndrome, 921–922
- Digestive enzyme deficiency, 606–608
- Digibind (digoxin immune Fab), 89
- Digital rectal examination, 993
- Digitalis, 560
- Digoxin, 86–92
- Digoxin immune Fab (Digibind), 89
- 1,25-Dihydroxy vitamin D. *See* Vitamin D
- Dimeric inhibin-A (DIA), 614
- Diphtheria, 501
- Diphtheroid, 501
- Diphyllobothrium* infection, 908–909, 1218–1219
- Dipstick urinalysis, 1192–1199
- Dipyridamole, blood pool imaging, 237–241
- Direct antiglobulin testing (DAT), 457–458
- Direct contact transmission of pathogen, 1277
- Direct platelet-bound IgG/IgM, 948–949
- Direct strep screen, 680–681

- Discoid lupus erythematosus, 212–214
- Disease transmission, isolation precautions, 1277–1284
- Disk herniation, 446–449, 571–572
 electromyography for, 565–567
 MRI for, 848–850
- Dislocation(s), 147
 arthroscopy in, 147
 bone scan for, 246
 x-ray of, 1028
- Disopyramide, 86–92
- Displaced lens, 676–677
- Disseminated carcinoma, 1087–1088
- Disseminated intravascular coagulation (DIC)
 aPTT in, 927–929
 D-dimer in, 539
 factors in, 339–341
 plasminogen levels in, 946–947
 platelet count in, 380–382
 protein C levels in, 1001–1003
 prothrombin time and, 1008–1011
- Disseminated lupus erythematosus, 191–194, 400–403
- Disseminated tuberculosis, 1228
- Distended bladder, 1232
- Diuretic(s)
 hyaline casts and, 1196
 lithium and, 133–134
 magnesium level and, 825–828
 urine potassium and, 980
- Diuretic abuse
 aldosterone levels in, 20–22
 phosphorus levels and, 943–945
 sodium levels and, 1065–1067
- Diuretic therapy
 potassium levels and, 980–982
 sodium levels and, 1068–1071
- Diurnal variation
 phosphorus levels and, 940–941
 prolactin and, 992
 sodium levels and, 1069
 transferrin level and, 1106–1108
- Diverticula
 barium swallow for, 160–162
 bronchoscopy for, 250
 capsule endoscopy for, 274–276
 colonoscopy for, 347–350
 cystoscopy for, 524
 EGD and, 587
 Meckel's, scan for, 865–867
 proctosigmoidoscopy for, 985–988
 retrograde urethrography for, 1183–1185
 ultrasonography for, 1140–1141
 upper GI series for, 1172–1174
 voiding cystourethrography for, 527–529
- Diverticular disease
 barium enema for, 157–159
 capsule endoscopy for, 274–276
 esophagogastroduodenoscopy for, 586–589
 fecal analysis for, 603–604
- Diverticulosis, 651–654
- Dizziness
 Holter monitoring in, 707–709
 magnesium toxicity and, 822–824
 methemoglobin and, 874
 salicylate intoxication and, 227–232
- DLE (discoid lupus erythematosus), 212–214
- DNA ploidy, in breast cancer, 177, 178
- DNA synthesis, 1217
- DNase (deoxyribonucleic acid) antibody, 122–124
- Dohle body, 366
- Dopamine, 286–290, 712
- Doppler echo, 551–554
- Doppler flow study, 950, 1168–1169
- Doppler ultrasonography
 arterial
 carotid studies with, 1126–1128
 extremity studies with, 1128–1131
 cardiac, 551–557
 venous, extremity studies with, 1168–1171
- Double contrast barium enema, 602
- Double-stranded DNA herpesvirus, 1206
- Double-stranded DNA retrovirus, 695
- Down's syndrome, 334
- AFP levels in, 613–617
 LAP levels in, 795–797
 testosterone and, 1085–1086
 uric acid level in, 1186–1188
- Doxepin, 124–128
- Drepanocyte, 364, 392
- Dressler's syndrome, 932–934
- Droplet precautions, 1283–1284, 1288
- Droplet transmission of pathogen, 1278
- Drowning, near
 blood gas analysis in, 226–232
 potassium levels and, 975–978
- Drug(s)
 acquired methemoglobinemia and, 874–875
 aPTT and, 927
 beta₂-microglobulin and, 881
 BUN level and, 1178–1179
 cholinesterase enzyme and, 1031
 D-xylose level and, 547–550
 effect on EEG, 563
 eosinophil count and, 573–575
 erythrocyte protoporphyrin levels and, 576–577

Drug(s) (continued)

- erythrocyte sedimentation rate and, 577–578
 - erythropoietin level and, 581
 - exercise stress test and, 595–597
 - FDG-PET scan imaging and, 599
 - fecal analysis and, 603
 - fibrin degradation product and, 618–619
 - fibrinogen level and, 621
 - folate levels and, 627
 - follicle-stimulating hormone levels and, 630
 - free thyroxine level and, 1100–1101
 - free triiodothyronine levels and, 1112–1113
 - fructosamine level and, 632
 - gallium scan and, 637
 - gastric acid stimulation test and, 640–642
 - gastric emptying scan and, 643
 - gastrin levels in, 645–647
 - GGT levels and, 670
 - glucose levels and, 660
 - glucose tolerance test and, 666–669
 - glycated hemoglobin A_{1c} and, 673
 - haptoglobin level and, 686–687
 - homocysteine level and, 710–711
 - homovanillic acid and, 712–713
 - human chorionic gonadotropin and, 716
 - human growth hormone and, 683
 - 5-hydroxyindoleacetic acid level and, 725
 - immunoglobulin E level and, 734
 - immunoglobulin level with, 738
 - immunoglobulin levels and, 731
 - insulin levels and, 745–747
 - iron level and, 762
 - ketone levels and, 768
 - lactic acid levels and, 777
 - LAP levels and, 796
 - lipase levels and, 798
 - lupus anticoagulant antibody and, 811
 - lutinizing hormone secretion and, 815
 - magnesium level and, 823, 826
 - metanephrine and, 872
 - methemoglobinemia and, 874–876
 - muscle abnormality and, 566–567
 - myocardial perfusion heart scan and, 890
 - osmotic concentration and, 900
 - oxalate levels and, 911
 - parathyroid hormone and, 921–922
 - PET scan and, 964, 967, 971
 - phosphorus levels and, 940–941, 943
 - plasminogen levels and, 946
 - platelet antibody and, 948–949
 - porphyrin levels and, 960–962
 - potassium levels and, 976–977, 980
 - progesterone and, 989–990
 - prolactin and, 991–992
 - protein C levels and, 999, 1002
 - protein level and, 997, 1004–1005
 - prothrombin time and, 1009
 - PSA levels and, 994
 - pulmonary function study and, 1016
 - radioactive iodine uptake and, 1022
 - renin value and, 1036–1037
 - renogram and, 1040
 - reticulocyte count and, 1043–1044
 - semen analysis and, 1058
 - sickle cell screen and, 1060
 - sodium levels and, 1066–1067, 1069
 - stool analysis and, 908
 - TBG level and, 1098
 - testosterone and, 1085–1086
 - thyroglobulin values and, 1087–1088
 - thyroid scan and, 1090
 - total iron-binding capacity and, 765
 - total thyroxine level and, 1103
 - total triiodothyronine levels and, 1115–1116
 - transferrin level and, 1106–1108
 - triglyceride levels and, 1110–1111
 - uric acid level and, 1187–1188, 1189–1190
 - urine urea nitrogen level and, 1181–1182
 - vanillylmandelic acid level and, 1203
 - vitamin B₁₂ and, 1218
 - vitamin D and, 1221
 - vitamin E and, 1223
 - vitamin K and, 1225–1226
 - vitamin levels and, 1228–1229
 - zinc level and, 1235–1236
- Drug abuse
- intravenous, syphilis serology testing for, 1082–1083
 - types of, 544–547
- Drug dependence, 126–128
- Drug overdose, 544–547
- Drug reaction
- cardiolipin antibody in, 114
 - eosinophil count in, 573–575
- Drug regimen, pulse oximetry and, 1018–1020
- Drug therapy
- monitoring and toxicology, laboratory tests for, 1249–1250
 - urinalysis for, 1193
- Drug toxicity
- platelet count in, 380–382
 - WBC and differential in, 400–403

- Drug-induced anemia, 457–458
Drug-induced lupus erythematosus, 106–108
Drusen, macular, 1215–1217
Dry eye syndrome
 Schirmer tear test for, 1055–1056
 slit-lamp biomicroscopy for, 1062–1064
DST (dexamethasone suppression test), 7–12, 464–467
Dual-energy x-ray absorptiometry (DEXA, DXA), 242–245
Dubin-Johnson syndrome, 164–166
Duchenne's muscular dystrophy
 aldolase levels in, 18–19
 muscle biopsy for, 205–208
 pyruvate kinase levels in, 1020
Ductal carcinoma, 1143–1147
Dumping syndrome, 642–645
Duodenal cancer
 capsule endoscopy for, 274–276
 upper GI series for, 1172–1174
Duodenal diverticula, UGI series and, 1172–1174
Duodenal obstruction, 52–53
Duodenal papilla tumor, 321–324
Duodenal ulcer
 capsule endoscopy for, 274–276
 esophagogastroduodenoscopy for, 586–589
 gastric acid stimulation test and, 639–642
 gastric emptying scan for, 642–645
 gastrin stimulation test for, 645–647
Duodenitis
 capsule endoscopy for, 274–276
 esophagogastroduodenoscopy for, 586–589
Duodenum
 capsule endoscopy of, 274–276
 esophagogastroduodenoscopy of, 586–589
Duplicated kidney, ultrasonography of, 1144–1147
DVT. *See* Deep venous thrombosis (DVT)
Dwarfism, 682–684
DXA (dual-energy x-ray absorptiometry), 242–245
D-xylose tolerance test, 547–550
Dye(s)
 allergic reaction to, 624
 iodinated
 angiography and, 59, 63, 67, 71, 74, 79
 hysterosalpingography and, 728
 intravenous pyelography and, 756
 voiding cystourethrography and, 527
Dyostosis, 1028–1029
Dysautonomia, catecholamines and, 287–290
Dyscrasia
 RBC count and, 384
 RBC indices and, 389
 RBC morphology and inclusions, 393
 WBC count and, 399
Dyserythropoietic anemia, 683
 PNH and, 685
Dysfibrinogenemia
 fibrinogen level in, 620–622
 prothrombin time and, 1008–1011
Dysgammaglobulinemia, 799–800
Dysglobulinemia
 apolipoprotein B and, 141–143
 LDLC level in, 327–329
Dyskinesia, 239–241
Dyspepsia, 586–589
Dysphagia
 esophageal manometry for, 583
 esophagogastroduodenoscopy for, 586–589
Dysplasia, 79–82
 abdominal angiography of, 58–61
 carotid angiography of, 67–69
 radiography for, 1028–1029
Dyspnea, 1015–1017
Dysproteinemia, 462–463
Dysrhythmia
 abdominal laparoscopy and, 783
 exercise stress test for, 595–597
 transesophageal echocardiography and, 555
Dysuria, bladder ultrasonography and, 1139–1141
- E**
E2 (estradiol), 589–590
Ear
 audiometry and, 153–156
 bacterial culture of, 492–497
 otoscopy of, 905–907
 tuning fork test of, 1122–1125
Ear canal, obstruction of, 906–907
Ear culture, 492–497
Ear injury, otoscopy for, 905–907
Ear pain, 905–907
Earlobe, pulse oximetry of, 1018–1020
Eating disorders, 126–128. *See also*
 Anorexia nervosa
 Eaton-Lambert syndrome, 566–567
Ebola virus, 518–519
EBP (evoked brain potential), 590–594
EBV. *See* Epstein-Barr virus
EBV-specific serology, in infectious mononucleosis, 742–744. *See also*
 Infectious mononucleosis

- Ecchymosis, bleeding time, 220
 ECG (electrocardiography), 557–561
Echinococcus infection, 27–28
 Echocardiography
 of heart, 551–554
 transesophageal, 554–557
 Echovirus, 517–519
 Eclampsia
 eosinophil count in, 573–575
 fibrinogen level in, 620–622
 ketone level in, 767–770
 uric acid level in, 1186–1188
 WBC and differential in, 400–403
 Ectopic ACTH-producing tumor, 9–10, 465, 542–543
 Ectopic ADH-producing tumor, 129
 Ectopic gastric mucosa scan, 864–867
 Ectopic HCG-producing tumor, 716
 Ectopic kidney, 1145–1147
 Ectopic pregnancy
 amylase levels in, 52–53
 gynecologic laparoscopy for, 786–788
 pelvic CT of, 433–437
 ultrasonography for, 1136–1139, 1156–1158
 Ectopic prolactin-secreting tumor, 991–993
 Ectopic secretion, calcitonin stimulation test for, 257–259
 Ectopic spleen, 1164–1166
 Ectopic TSH-producing tumor, 1093–1095
 Ectropion, 1062–1064
 Eczema
 eosinophil count in, 573–575
 immunoglobulin E level in, 734–735
 immunoglobulin levels in, 27–28
 Edema
 brain CT of, 417–420
 pulmonary. *See* Pulmonary edema
 retinal, 623–625
 skeletal muscle CK-MM and, 474–475
 sweat chloride values in, 312–314
 venogram and, 1208
 Edwards' syndrome, 334
 AFP levels in, 615–617
 EEG (electroencephalography), 562–564
 Effusion
 joint, radiography for, 1028–1029
 pericardial
 chest x-ray for, 302–303
 echocardiography for, 551–557
 MRI for, 844–846
 peritoneal, 936–938
 pleural, 956–958
 blood gas analysis in, 226–232
 chest x-ray for, 302–303
 MRI for, 843–846
 pleural fluid analysis and, 956–958
 thoracic CT for, 454–456
 pulmonary, perfusion and ventilation scans in, 804, 808
 skeletal x-ray of, 1028
 synovial, 1078
 EGD (esophagogastroduodenoscopy), 190, 586–589
 eGFR (estimated glomerular filtration rate), 477
 Ejaculatory obstruction, 1058–1059
 EKG (electrocardiography), 557–561
 Elbow, MRI of, 847
 Elderly adult, 542–543
 age-specific communication with, 1265–1268
 angiography in, 59, 63, 67, 71, 75, 79
 Electrocardiography (ECG), 557–561
 Electrodiagnostic study, 568–570
 Electroencephalography, 562–564
 Electrolyte balance, 1068
 Electrolyte disturbance/imbalance
 blood gas analysis in, 226–232
 carbon dioxide levels in, 277–279
 electrocardiogram and, 560
 electrocardiogram for, 559–561
 magnesium and, 825
 Electromyography (EMG), 565–567
 cystometry and, 520
 pelvic floor sphincter, 568–570
 Electroneurography (ENG), 565, 570–572
 Electrophoresis, 1003
 EM (esophageal manometry), 582–585
 EMA (endomysial antibody), 115–117
 Embolism (embolus)
 angiography of, 58, 62, 78
 arterial, 950–954
 CT angiography of, 408–412
 D-dimer and, 539
 erythrocyte sedimentation rate and, 577–578
 fibrin degradation product and, 618–619
 lactic acid levels and, 777–779
 lung perfusion scan for, 805–807
 occlusion from, ultrasonography in, 1129–1131
 plethysmography of, 950
 pulmonary. *See* Pulmonary embolism
 renal artery, 1039–1042
 skeletal muscle CK-MM and, 474–475
 thoracic CT for, 454–456
 transfusion reaction and, 1271
 venography of, 1208
 Embolization, uterine fibroid, 1199–1202
 Embryonal gonadal teratoblastoma, 614–617

- Emesis. *See* Vomiting
- EMG (electromyography), 565–567
 cystometry and, 520
 pelvic floor sphincter, 568–570
- Emphysema
 blood gas analysis in, 226–232
 carbon dioxide levels in, 277–279
 lung perfusion scan for, 805–807
 lung ventilation scan for, 808–810
 plethysmography for, 951–954
 pulmonary angiography of, 74
 pulmonary function study for, 1016–1017
- Empty sella, 859–861
 pituitary CT of, 438
- Empyema, 956–958
 pleural fluid analysis and, 956
 subdural, 837–839
- ENA (antiextractable nuclear antigen), 104–108
- Encephalitis
 cerebrospinal fluid analysis for, 295–298
 EEG determining, 563–564
 mumps and, 883
- Encephalopathy, lead, 790
- Endarterectomy, 562
- Endocarditis
 antistreptolysin O antibody in, 110–111
 bacterial culture for, 500–501
 cryoglobulin detection in, 485–486
 echocardiography for, 551–554
 erythrocyte sedimentation rate and, 577–578
 mitral valve, cardiolipin antibodies and, 114
 RBC count in, 385–388
 VDRL testing and, 1081
- Endocardium, 558
- Endocervical carcinoma in situ, 916
- Endocrine disorder
 natural products affecting, 1274–1275
 sodium levels and, 1068–1071
- Endocrine system
 diagnostic tests for, 1239
 laboratory tests for, 1238–1239
- Endoluminal wall, abnormal, 426–429
- Endometrial carcinoma, 284–285
- Endometrioma, 1156–1158
- Endometriosis
 cancer antigen levels in, 284–285
 gynecologic laparoscopy for, 786–788
 Pap smear and, 917
- Endomysial antibody, 115–117
- Endomysial antibody (EMA), 115–117
- Endoscopy, 586
- Endoscopic retrograde cholangiopancreatography (ERCP), 321–324, 798
- Endoscopy
 capsule, 273–276
 esophagogastroduodenoscopy, 190, 586–589
 for gastrointestinal bleeding, 651–654
 lower, 346–350
- Endotracheal tube, chest x-ray and, 301–303
- End-stage liver disease, 1110–1111
- End-stage renal disease, ultrasonography of, 1145–1147
- Enema, barium, 157–159
- ENG (electroneurography), 565, 570–572
- Entamoeba histolytica* infection, 908–909
- Enteritis
 capsule endoscopy in, 273
 fecal fat and, 606–608
 folate level in, 627–628
 prothrombin time and, 1009–1011
- Enterobiasis, 908–909
- Enterobius vermicularis* infection, 908–909
- Enterocolitis, fecal analysis for, 602–604
- Enterogastric reflux, hepatobiliary scan for, 701–704
- Enteropathy(ies)
 A/G ratios in, 16
 gluten-induced, 547–550
 protein-losing, 997
- Enterovirus, 517–519
- Entropion, 1062–1064
- Enuresis, 126–128
- Environmental temperature, plethysmography and, 952
- Enzyme(s). *See* specific enzyme
- Enzyme abnormality
 amniotic fluid analysis for, 48–51
 bilirubin levels in, 164–166
- Enzyme deficiency
 apolipoprotein A and B, 141–143
 glucose levels in, 659–662
 protoporphyria and, 575
- Enzyme precursor, 338
- Enzyme/cofactor deficiency, 326–329
- Eosinophil count, 572–575
- Eosinophil cell, 398
- Eosinophilic gastroenteritis, 547–550
- Epicardium, 558
- Epidermophyton*, 515–516
- Epididymal cyst, 1162–1163
- Epididymitis, 1161–1163
- Epidural block, 182–185
- Epidural hematoma, 417–420
- Epigastric pain
 esophagogastroduodenoscopy for, 586–589
 pancreatic CT in, 430

- Epigastric pain (*continued*)
 upper GI series for, 1172–1174
- Epilepsy
 amino acid levels in, urine test for, 40
 anticonvulsants for, 119–121
 cardiolipin antibody in, 114
 FDG-PET scan for, 599–601
- Epinephrine, 286–290
 homovanillic acid and, 712
 vanillylmandelic acid and, 1203
- Epistaxis, 926–929
- Epithelial cell abnormality, 915
- EPO (erythropoietin), 580–582
- Epstein-Barr virus (EBV)
 and infectious mononucleosis,
 742–744. *See also* Infectious
 mononucleosis
 culture for, 517–519
 Lyme antibody and, 816
- Equilibrium phase, 808
- ER (estrogen receptor) assays, in breast
 cancer, 177, 178
- ERCP (endoscopic retrograde cholan-
 giopancreatography), 321–324, 798
- Ergocalciferol, 1220
- Erythema infectiosum (fifth disease),
 929–931
- Erythema migrans, Lyme disease and,
 816
- Erythroblastosis fetalis
 bilirubin levels in, 163–166
 human chorionic gonadotropin level
 in, 716–717
- Erythrocyte(s). *See* Red blood cell *entries*
- Erythrocyte protoporphyrin test, free,
 575–577
- Erythrocyte sedimentation rate (ESR),
 577–580
- Erythrocytosis
 hematocrit in, 369–372
 hemoglobin in, 374–378
- Erythroleukemia, 690
- Erythropoiesis
 iron role in, 761, 764
 regulation of, 580
- Erythropoietic protoporphyria, 576–577
- Erythropoietin (EPO), 580–582
- ESBL (extended spectrum beta lacta-
 mase), 512–514
- Escherichia coli*
 bacterial culture for, 494–497
 stool culture for, 506–509
 urine culture for, 512–514
- Esophageal acid study, 582, 585
- Esophageal bleeding, 555
- Esophageal cancer
 CEA and, 284
 upper GI series for, 1172–1174
- Esophageal diverticulum
 EGD and, 587
 UGI series and, 1172
- Esophageal function test, 582
- Esophageal manometry (EM), 582–585
- Esophageal motility study, 582
- Esophageal motor disorders
 gastric emptying scan and, 643
 GER scan and, 649
- Esophageal mucosa, 586–589
- Esophageal perforation/rupture, 587,
 956–958
 barium swallow and, 160
 capsule endoscopy in, 274
 pleural fluid analysis and, 956
 upper GI series and, 1172
- Esophageal scleroderma, 583
- Esophageal stenosis
 capsule endoscopy for, 274–276
 esophagogastroduodenoscopy for,
 586
- Esophageal stricture
 EGD for, 586
 UGI series and, 1172
- Esophageal ulcer, 160–162
- Esophageal varices
 capsule endoscopy for, 274–276
 esophagogastroduodenoscopy for,
 586–589
 fecal analysis for, 603–604
- Esophageal x-ray, 160–162
- Esophagitis
 barium swallow for, 160–162
 capsule endoscopy for, 274–276
 esophageal manometry for, 583
 esophagogastroduodenoscopy for,
 586–589
 fecal analysis for, 603–604
- Esophagogastroduodenoscopy (EGD),
 190, 586–589
- Esophagus
 barium swallow study of, 160–162
 capsule endoscopy of, 273–276
 esophagogastroduodenoscopy of,
 586–589
 gastric emptying scan of, 642–645
 manometry of, 582–585
 thoracic CT for, 454–456
 upper GI series of, 1171
- ESR (erythrocyte sedimentation rate),
 577–580
- Essential hypertension
 renin and, 1036
- Essential thrombocythemia, 379–382
- Estimated glomerular filtration rate
 (eGFR), 477
- Estradiol (E2), 589–590
- Estril, in triple-marker testing, 715

- Estrogen
 copper and, 462–463
 DHEAS and, 542
 Estrogen receptor (ER) assays, in breast cancer, 177, 178
 Estrogen therapy
 alpha₁-antitrypsin levels in, 138–139
 osteoporosis and, 344
 TBG level in, 1098–1099
 transferrin level in, 1106–1108
 Estrogen-producing tumor, 589–590
 Ethanol. *See* Alcohol *entries*
 Ethanolamine, 39–41
 Ethosuximide, 117–121
 Ethylene glycol poisoning, 910–912
 calcium oxalate crystals in, 1196
 hyperoxaluria in, 910
 serum osmolality and, 899
 Euthyroidism, 1093–1095
 Evoked brain potential, 590–594
 Evoked potential response, 590
 Ewing's sarcoma, 170–172
 bone biopsy of, 170
 bone scan of, 246
 Excision biopsy, 212–214
 Excretory phase, 1039–1042
 Excretory uroteropyelography, 1045
 Exercise
 antidiuretic hormone and, 129–130
 catecholamine levels and, 287–290, 1203
 effect on ECG, 560
 glucose levels in, 659–662
 glucose tolerance test and, 667–669
 HDLc level in, 326–329
 human growth hormone levels in, 683–684
 lactic acid levels and, 777–779
 microalbumin and, 877–879
 myoglobin levels in, 894–895
 platelet count in, 379–382
 potassium levels and, 975–978
 protein levels in, 1004–1006
 renin value and, 1037
 total thyroxine level and, 1102–1104
 uric acid level in, 1186–1188
 urine creatinine clearance test and, 481–484
 WBC and differential in, 399–403
 Exercise stress test, 594–597
 Exercise-induced hypertension, 595–597
 Exfoliative dermatitis, 626–628
 Exogenous steroid therapy, 11
 Exophthalmos, 437–441
 Expectorated specimen, 532
 Expiratory pressure, 1012–1017
 Expiratory reserve volume, 1013
 Exposure Control Plan, 1290
 Extended spectrum beta lactamase (ESBL), 512–514
 External ear canal, 905–907
 obstruction of, 154–156
 Extragenital tumor, 1085–1086
 Extrahepatic duct obstruction, 24–26
 Extratesticular lesion, 1161–1163
 Extrauterine pregnancy, 728–730
 Extremity studies
 arterial Doppler, 1168–1169
 venous Doppler, 1128–1131
 Extrinsic allergic alveolitis, 727
 Exudate, 932, 935, 954, 1215–1217
 Eye
 aqueous humor of, 752–755
 A-scan ultrasonography of, 1131–1133
 fluorescein angiography of, 623–625
 fundus photography of, 633–635
 gonioscopy of, 675–677
 intraocular muscle function of, 750–752
 intraocular pressure of, 752–755
 nerve fiber analysis of, 896–898
 pachymetry of, 913–914
 refraction of, 1032–1035
 Schirmer tear test, 1055–1056
 slit-lamp biomicroscopy of, 1062–1064
 visual field test, 1215–1217
 Eye culture, 492–497
 Eye disease, nerve fiber analysis of, 896–898
 Eye lesion, 591–594
 Eye protection, 1280
 Eyelash, slit-lamp biomicroscopy of, 1061
 Eyelid
 Schirmer tear test, 1055–1056
F
 FA (fluorescein angiography), 623–625
 Face, MRI of, 836
 Face shield, 1280
 Factitious hypoglycemia
 C-peptide levels in, 468–469
 insulin antibody and, 748–749
 Factor D. *See* Fibrinogen
 Factor deficiency
 aPTT in, 927–929
 vitamin B₁₂ and, 1218–1219
 Factor I, 338
 Factor II, 338, 1008
 Factor III, 338
 Factor IV, 338
 Factor V, 338, 461, 1008
 Factor V Leiden, 999
 Factor VII, 338, 1008

- Factor VIII, 1008
- Factor VIII:C, 338, 1008
- Factor IX, 338, 1008
- Factor X, 338
- Factor XI, 338
- Factor XII, 338, 1008
- Factor XIII, 338
- Fallopian tubes
 - gynecologic laparoscopy of, 785–788
 - hysterosalpingography of, 727
- False passages, retrograde urethrography, 1045–1048
- Familial cholestasis, sweat chloride and, 311–314
- Familial enzyme and lipoprotein deficiency, 140–143
- Familial hyperlipoproteinemia, 141–143
- Familial hyperphosphatemia, 24–26
- Familial immunodeficiency disorder, 734–735
- Familial periodic paralysis, 976–978
- Fanconi's syndrome
 - amino acid levels in, urine test for, 40
 - blood gas analysis in, 227–232
 - platelet count in, 380–382
 - protein levels in, 1004–1006
 - uric acid level in, 1187–1188, 1189–1191
 - urinary calcium levels in, 268–271
- Farsightedness, 1032–1035
- Fasciola hepatica* infection, 908–909
- Fasciolopsis buski* infection, 908–909
- Fasting
 - hepatobiliary scan and, 702
 - ketone level in, 767–770
- Fasting blood sugar (FBS), 657
- Fat
 - cortisol and, 464
 - ketone bodies and, 767
- Fat accumulation, 855–857
- Fat malabsorption
 - aPTT in, 926–929
 - prothrombin time and, 1008–1011
 - vitamin K and, 1225–1226
- Fatigue
 - methemoglobin and, 874–876
 - tuberculin skin test for, 1118–1122
- Fatty acid
 - fecal fat and, 605–608
 - oxidation of, 1222–1224
 - triglycerides and, 1108–1111
- Fatty diet
 - apolipoprotein A and, 141–143
 - fecal fat and, 607
 - HDLC and LDLC levels in, 327–329
 - ketone level in, 767–770
 - rheumatoid factor and, 1049–1050
 - total cholesterol level in, 330–333
- Fatty infiltration, pancreatic, MRI of, 851–854
- Fatty liver
 - alanine aminotransferase levels in, 13–15
 - aspartate aminotransferase levels in, 150–152
 - CT of, 413
- FBP (fibrin breakdown product), 617–619
- FBS (fasting blood sugar), 657. *See also* Glucose
- FDG (fluorodeoxyglucose), 598
- FDG-PET scan, 598–601
- FDP (fibrin degradation product), 617–619
- Fe. *See* Iron (Fe)
- Febrile nonhemolytic transfusion reaction, 1270
- Feces, 602–604
 - abdominal laparoscopy and, 783
 - analysis of, 602–604
 - appearance of, 603
 - blood in, 603
 - barium enema and, 157
 - colonoscopy for, 347
 - CT colonoscopy for, 426
 - proctosigmoidoscopy for, 985
 - collection of, 1263
 - color of, 603
 - culture of, 506–509, 514–516
 - fat in, 605–608
 - gynecologic laparoscopy and, 786
 - hysterosalpingography and, 728
 - intravenous pyelography and, 756
 - lymphangiography and, 819
 - ova and parasites in, 603–604, 908–909
 - retrograde ureteropyelography and, 1046
 - ultrasonography and, 1150, 1153, 1156, 1159, 1164
 - uterine fibroid embolization and, 1200
 - vertebroplasty and, 1212
 - vitamin D and, 1220–1221
- Felty's syndrome
 - antineutrophilic cytoplasmic antibodies in, 103–104
 - beta₂-microglobulin levels in, 880–883
 - WBC and differential in, 400–403
- Female. *See* Woman
- Feminization, 589–590
- Femoral head, MRI of, 847–850
- FEP (free erythrocyte protoporphyrin), 575–577
- Fern test, 46

- Ferritin, 608–610, 765
- Fertility study. *See also* Infertility
ultrasonography for, 1156–1158
- Fertilization
human chorionic gonadotropin levels
and, 715
uterine fibroid embolization and,
1199
- Fe-Sat (iron-binding capacity, total),
764–766
- Fetal age sonogram, 1134–1139
- Fetal anomaly
chorionic villus biopsy for, 185–188
ultrasonography for, 1136–1139
- Fetal blood
hemoglobin electrophoresis and,
689–691
lecithin/sphingomyelin ratio and, 792
- Fetal contraction stress test, 1135
- Fetal death, 1136–1139
AFP and, 615
cardiolipin antibodies and, 114
FDP and, 618
lupus anticoagulant antibodies and,
811
- Fetal distress, 615–617
AFP and, 615
L/S ratio and, 792
- Fetal fibronectin, 611–612
- Fetal gestational age
AFP and, 613–617
ultrasonography for, 1134–1139
- Fetal heart rate (FHR), 1134
- Fetal hemoglobin, 772–774
hereditary persistence of, 689
- Fetal hemolytic disease, 47–51
- Fetal Hgb, 689–691
- Fetal hydrops, 1136–1139
- Fetal loss, 811–813
- Fetal lung, 792–795
- Fetal malpresentation, ultrasonography
of, 1136–1139
- Fetal nonstress test, 1134, 1135
- Fetal position, 1136–1139
- Fetal Rh incompatibility, 459–460
- Fetal scalp sampling, 1256
- Fetal stress test, 1135
- Fetal transfusion, ultrasonography of,
1136–1139
- Fetal-maternal hemorrhage (FMH), 773
- alpha₁-Fetoprotein (AFP), 613–617
amniotic fluid analysis and, 47, 48
quad-marker testing and, 613, 715
triple-marker testing and, 613, 614,
715
- Fetus, amniotic fluid analysis and,
45–51
- FEV (forced expiratory flow), 1013
- Fever. *See also specific types, e.g.,* Rheumatic
fever
acetaminophen/acetysalicylic acid
for, 54
albumin/globulin ratio, 16–18
amino acid levels in, blood test for,
37–38
blood culture for, 498, 500
blood gas analysis in, 226–232
carbon dioxide levels in, 278–279
hyaline casts in, 1196
infectious mononucleosis and,
742–744
Lyme disease and, 816
nonhemolytic transfusion reaction
and, 1270
of unknown origin
gallium scan for, 636–638
white blood cell scan for,
1231–1233
sodium levels and, 1065–1067
urine porphyrins and, 960
viral culture for, 517
white blood cell scan for, 1231–1233
- fFN (fetal fibronectin), 611–612
- FHR (fetal heart rate), 1134–1139
- Fiberoptic bronchoscopy, 252
- Fibrin
APTT and, 925–929
plasminogen and, 945–947
- Fibrin breakdown product (FBP),
617–619
- Fibrin clot, 1007–1011
- Fibrin degradation product, 617–619
- Fibrin split product (FSP), 617–619
- Fibrinogen, 620–622
circulating, 577
clot retraction and, 336
degradation of, 927
- Fibrinogen disorder, 220
- Fibrinolysis
D-dimer and, 539
fibrinogen level in, 620–622
- Fibrinolytic therapy, 946–947
- Fibroadenolipoma, 1143–1147
- Fibroadenoma, 1143–1147
- Fibroid
gynecologic laparoscopy for, 786–788
hysterosalpingography for, 728–730
MRI for, 855–857
pelvic CT of, 433–437
ultrasonography for, 1156–1158
- Fibroid embolization, 1199–1202
- Fibroma, skin biopsy for, 212–214
- Fibronectin, fetal, 611–612
- Fibrosarcoma
glucose levels in, 659–662
MRI for, 848–850

- Fibrosis
- breast, ultrasonography for, 1143–1147
 - cystic. *See* Cystic fibrosis
 - pancreatic, ERCP in, 321
 - plethysmography for, 951–954
 - pulmonary. *See* Pulmonary fibrosis
 - thyroid scan for, 1090–1092
- Fifth disease (erythema infectiosum), 929–931
- Filter paper test, 1095
- Fine-needle aspiration biopsy
- bone marrow biopsy for, 174–177
 - breast ultrasonography for, 1142–1147
 - pancreatic ultrasonography for, 1152–1154
 - parathyroid ultrasonography for, 1166–1168
 - prostatic ultrasonography for, 1158–1160
 - scrotal ultrasonography for, 1161–1163
- Finger, venipuncture of, 1253–1254
- Fingertip, pulse oximetry, 1018–1020
- First morning urine. *See* Urine specimen
- FISH (fluorescence in situ hybridization)
- in bladder cancer, 218
 - in breast cancer, 177, 178
- Fish tapeworm, 1218–1219
- Fish-eye disease, 326–329
- Fissure, anal
- fecal analysis and, 603–604
 - proctosigmoidoscopy for, 985–988
- Fistula
- albumin/globulin ratio, 16–18
 - barium enema for, 157–159
 - blood gas analysis in, 227–232
 - chloride values in, 308–310
 - CT angiography of, 408–412
 - cystoscopy for, 524–526
 - hepatobiliary scan for, 701–704
 - hysterosalpingography for, 728–730
 - retrograde urethrography for, 1183–1185
- Five-hour glucose tolerance test, 665–669
- Fixed upper airway obstruction, 1014
- Flaccid bladder, cystometry in, 545
- Flank pain, bladder ultrasonography and, 1139
- Flavivirus, 517–519
- Flecainide, 86–92
- Flexible bronchoscopy, 249–253
- Flexible fiberoptic endoscope, for proctosigmoidoscopy, 985–988
- Flexible fiberoptic sigmoidoscopy, 985–988
- Flexible proctosigmoidoscopy, 985–988
- Flexible sigmoidoscopy, 602
- Flow-volume loop, 1012–1017
- Fluid balance/imbalance
- calcium and, 260–263
 - chloride and, 307–310
 - Hgb, 690
 - urinalysis and, 1193
- Fluid retention
- hematocrit in, 369–372
 - hemoglobin in, 374–378
 - MRI for, 855–857
- Fluid specimen, 1263
- Fluorescein angiography (FA), 623–625
- Fluorescence in situ hybridization (FISH)
- in bladder cancer, 218
 - in breast cancer, 177, 178
- Fluorescent treponemal antibody testing (FTA-ABS), 1081
- Fluoride, 1031
- Fluorine-18, 598
- Fluorodeoxyglucose (FDG), 598
- Fluorodeoxyglucose (FDG)-PET scan, 598–601
- Fluoroscopy technique, 1172
- Fluorosis, 920–922
- Flushing, antidepressant toxicity and, 124–128
- FMH (fetal-maternal hemorrhage), 773
- Focal fibrosis, 1143–1147
- Focal radionuclide uptake, 971–973
- Focal seizure
- EEG determining, 563–564
 - PET scan for, 963–966
- Focal uptake, 971–973
- Folate/folic acid, 626–628
- Folate/folic acid deficiency
- alkaline phosphatase levels in, 25–26
 - amino acid levels in, urine test for, 40
 - bone marrow biopsy for, 174–177
 - haptoglobin level in, 686–687
 - homocysteine level and, 710–711
 - platelet count in, 380–382
 - RBC morphology in, 393–396
 - uric acid level in, 1189–1191
 - WBC and differential in, 399–403
- Folex, 739–742
- Follicle-stimulating hormone (FSH), 628–631
- Follitropin, 628
- Food. *See* Diet
- Foot
- MRI of, 847
 - venipuncture of, 1253–1254
 - x-ray of, 1027–1029
- Forced expiratory flow, 1013
- Forced expiratory volume, 1013
- Forced inspiratory flow, 1013–1014
- Forced vital capacity (in 1 second), 1013

Foregut carcinoid tumor, 724–726

Foreign body

- bronchoscopy for, 250–253
- chest x-ray for, 302–303
- colonoscopy for, 347–350
- otoscopy for, 906–907
- radiography for, 1028–1029
- upper GI series for, 1172–1174

Forward grouping, 233

Fracture

- alkaline phosphatase levels in, 24–26
- arthroscopy of, 147–149
- bone mineral densitometry for risk of, 242–245
- bone scan for, 245–248
- chest x-ray for, 302–303
- MRI for, 848–850
- radiography of, 1028–1029
- spinal CT for, 446–449
- vertebroplasty for, 1212
- x-ray of, 1027–1029

Framingham algorithm, 1108

FRC (functional residual capacity), 1013

Free erythrocyte protoporphyrin test, 575–577

Free thyroxine (FT₄), 1099–1101

Free triiodothyronine (FT₃), 1112–1113

Fructosamine, 631–633

Fructose, semen analysis and, 1057–1059

Fructose intolerance

- aldolase levels in, 18–19
- blood test for amino acid levels in, 37–38
- urine test for amino acid levels in, 40

FSH (follicle-stimulating hormone), 628–631

FSP (fibrin split product), 617–619

FT₃ (free triiodothyronine), 1112–1113

FT₄ (free thyroxine), 1099–1101

Fuchs endothelial dystrophy

- gonioscopy for, 676–677
- pachymetry and, 913–914

Fucosidosis, 311–314

Full colonoscopy, 346–350, 602

Functional residual capacity (FRC), 1013

Fundus photography, 633–635

Fungal culture, 500–501

Fungal infection

- ACE in, 82
- culture for, 500–501
- lymph node biopsy for, 202–205
- muscle biopsy for, 205–208
- sputum cytology for, 530–534

Fungal meningitis, 295–298

Fungal pericarditis, 932–934

FVC₁ (forced vital capacity in 1 second), 1013

G

Galactocele, 1143–1147

Galactorrhea, 991–993

Galactorrhea-amenorrhea syndrome, 989–990

Galactosemia

- amino acid levels in, urine test for, 40
- liver biopsy for, 194–197

Gallbladder

- radiofrequency ablation of, 1024
- ultrasonography of, 1147–1149

Gallbladder cancer

- alkaline phosphatase levels in, 24–26
- cancer antigen levels in, 284–285
- percutaneous transhepatic cholangiography for, 315–318
- ultrasonography for, 1148–1149

Gallbladder dilation

- abdominal CT of, 404–407
- kidney CT for, 442–445
- liver/biliary tract CT of, 412–416

Gallbladder disorder, hepatobiliary scan for, 701–704

Gallbladder inflammation. *See* Cholecystitis

Gallium scan, 636–638

Gallstones. *See* Cholelithiasis

Gamma-amino-butyric acid, 39–41

Gamma-aminoiso-butyric acid, 39–41

Gamma-glutamyl transpeptidase (GGT), 669–672

Gammopathy. *See also* Monoclonal gammopathy

- IFE and, 731–733
- IgA and IgG in, 735–736
- total protein and, 995–998

Ganglioblastoma

- catecholamine levels in, 287–290
- homovanillic acid level in, 712–714

Ganglion, 147–149

Ganglion cyst, arthroscopy of, 146–149

Ganglion nerve cell, 896–898

Ganglioneuroma

- catecholamine levels in, 287–290
- metanephrine levels and, 872–873
- vanillylmandelic acid level in, 1203–1205

Gangrene, ALD levels in, 18–19

Gangrenous gallbladder, 782–785

Gantry, 403, 408, 421, 429, 433, 441, 446, 449

Gardasil, 916

Gardnerella vaginalis, 494, 1195

Gas

- abdominal laparoscopy and, 783
- excessive, KUB study for, 771–772
- gynecologic laparoscopy and, 786
- hysterosalpingography and, 728

- Gas (*continued*)
- intravenous pyelography and, 756
 - lymphangiography and, 819
 - retrograde ureteropyelography and, 1046
 - ultrasonography and, 1137, 1140, 1146, 1150, 1153, 1156, 1159, 1164
 - uterine fibroid embolization and, 1200
 - vertebroplasty and, 1212
- Gas exchange
- pulmonary function study and, 1012–1017
 - pulse oximetry for, 1018–1020
- Gasoline, lead in, 789–791
- Gastrectomy, 666–669
- Gastric. *See also* Stomach *entries*
- Gastric acid
- chloride and, 307
 - reflux of. *See* Gastroesophageal reflux (GER)
- Gastric acid stimulation test, 639–642
- Gastric cancer
- CA 19–9 in, 284
 - capsule endoscopy for, 274–276
 - CEA and, 284
 - ceruloplasmin and, 299
 - gastric acid stimulation test for, 640–642
 - gastrin stimulation test for, 645, 646
 - GH tests and, 683
 - glucose and, 659
 - Helicobacter pylori* and, 687, 688
 - hexosaminidase level in, 705–706
 - human chorionic gonadotropin level in, 716–717
 - upper GI series for, 1172–1174
- Gastric emptying scan, 642–645
- Gastric lavage
- antiarrhythmic toxicity and, 89
 - antidepressant toxicity and, 124–128
 - antipsychotic toxicity and, 131–134
 - methemoglobin and, 874–876
- Gastric mucosa, Meckel's diverticulum scan, 864–867
- Gastric outlet obstruction
- esophagogastroduodenoscopy for, 586–589
 - gastric emptying scan for, 643–645
- Gastric outlet syndrome, gastric emptying scan and, 642–645
- Gastric perforation, 936–938
- Gastric polyp, 640–642
- Gastric radiography, 1171
- Gastric resection, 52–53
- Gastric strangulation, 936–938
- Gastric suctioning, 84–86, 227–232
- Gastric surgery, 1218–1219
- Gastric tumor. *See also* Gastric cancer
- gastrin stimulation test for, 645–647
 - growth hormone levels and, 683–684
 - UGI series and, 1171–1174
- Gastric ulcer
- capsule endoscopy for, 274–276
 - esophagogastroduodenoscopy for, 586–589
 - gastric acid stimulation test and, 640–642
 - gastric emptying scan for, 643–645
 - gastrin stimulation test for, 645–647
- Gastrin stimulation test, 645–647
- Gastritis
- capsule endoscopy for, 274–276
 - esophagogastroduodenoscopy for, 586–589
 - fecal analysis for, 603–604
 - gastric acid stimulation test and, 640–642
 - gastrin stimulation test for, 645–647
 - Helicobacter pylori* and, 687, 688
 - upper GI series for, 1172–1174
- Gastroenteritis
- barium enema for, 157–159
 - gastric emptying scan for, 643–645
 - radioactive iodine uptake and, 1022
 - thyroid scan and, 1091
 - viral culture for, 517–519
- Gastroenterostomy, 666–669
- Gastroesophageal reflux (GER), 582, 648
- EM for, 582, 583
 - gastric emptying scan for, 643–645
 - scanning for, 648–650
 - symptoms of, 648
 - upper GI series for, 1172–1174
- Gastrointestinal blood loss scan, 651–654
- Gastrointestinal cancer, 284–285, 474–475
- CA 19–9 in, 284
 - IgA and, 737
 - IgM and, 737
 - transferrin and, 1106
- Gastrointestinal disease
- colonoscopy for, 346–350
 - IgA, 735–736
 - natural products affecting, 1275
 - renin and, 1036–1039
 - vitamin A and, 1226–1230
 - vitamin K and, 1225
- Gastrointestinal disorders
- natural products affecting, 1275
 - renin value in, 1036–1039
- Gastrointestinal disturbance, 725
- Gastrointestinal fistula, 16–18
- Gastrointestinal hemorrhage
- abdominal CT of, 404–407
 - ammonia levels in, 44–45

- BUN level in, 1178–1180
 gastrointestinal blood loss scan for, 651–654
 MRI for, 833–835
- Gastrointestinal irritation, acetaminophen intoxication and, 54–57
- Gastrointestinal loss, potassium and, 976
- Gastrointestinal polyp, UGI series for, 1172–1174
- Gastrointestinal protein loss, 1102–1104
- Gastrointestinal series, upper, 1171–1174
- Gastrointestinal tract
 diagnostic tests for, 1240
 laboratory tests for, 1239–1240
 lead and, 789
- Gastrointestinal tract infarction, 474–475
- Gastroscope, 554
- Gaucher's disease
 AcP levels in, 4
 angiotensin-converting enzyme in, 82–83
 MRI for, 848–850
 platelet count in, 380–382
 WBC and differential in, 400–403
- Gaze position, ocular movement in, 750–752
- GBS (group B streptococcus), culture for, 492, 493, 494
- G-cell hyperplasia
 gastric acid stimulation test and, 639–642
 gastrin stimulation test for, 645–647
- GDH-PQQ test, 660
- Genetic defects
 chromosome analysis for, 334–336
 radiography for, 1028–1029
- Genital development, FSH and, 629
- Genital herpes. *See* Herpes
- Genital infection, 916–919
 culture for, 492–497
- Genital warts, 518–519
- Genitourinary disorder, 1275
- Genitourinary system
 diagnostic tests for, 1241
 laboratory tests for, 1240–1241
- Genitourinary tract infection
 ammonia levels in, 44–45
 urinalysis for, 1193
- Gen-Probe, 492
- Gentamicin, 92–96
- Geographic location, RAIU, 1021–1023
- GER. *See* Gastroesophageal reflux (GER)
- GER scan, 648–650
- Geriatric adult, 542–543
 age-specific communication with, 1265–1268
 angiography in, 59, 63, 67, 71, 75, 79
- Germ cell tumor, 715–717
- German measles serology, 1051
- Germinal follicle, 629–631
- Gestational age sonogram, 1134–1139
- Gestational diabetes
 ketone level in, 767–770
 vitamin B₆ and, 1228
- Gestational screen test, standard, 665–668
- GFR (glomerular filtration rate)
 estimated, 477
 renogram and, 1039–1042
- GGT (gamma-glutamyltransferase), 669–672
- GH. *See* Growth hormone (GH)
- Giardia*, 547–550
- Giardia lamblia* infection, 908–909
- Giardiasis, 908–909
- Gigantism
 blood creatinine clearance test and, 477–479
 human growth hormone levels in, 683–684
 urine creatinine clearance test and, 482–484
- Gilbert syndrome, 164–166
- Gingival bleeding
 aPTT in, 926–929
 prothrombin time and, 1008–1011
- Gland tissue destruction, 5–7
- Glandular enlargement, 1167–1168
- Glanzmann's thrombasthenia
 bleeding time in, 220
 clot retraction testing for, 336–337
- Glaucoma
 fluorescein angiography and, 624
 fundus photography and, 634
 gonioscopy for, 676–677
 intraocular pressure and, 752–755
 nerve fiber analysis for, 896–898
 pachymetry and, 913–914
 slit-lamp biomicroscopy and, 1062–1063
 visual field test for, 1215–1217
- Gleason grading, 208
- Gliadin antibody, 115–117
- Glioblastoma, 563–564
- Glomerular filtration rate (GFR)
 estimated, 477
 renogram and, 1039–1042
- Glomerulonephritis
 amino acid levels in, blood test for, 37–38
 anti-glomerular basement membrane antibody and, 99–100
 antineutrophilic cytoplasmic antibodies in, 103–104
 antistreptolysin O antibody in, 110–111

- Glomerulonephritis (*continued*)
BUN level in, 1178–1180
complement protein levels in, 357–358
intravenous pyelography for, 756–758
magnesium level and, 823–824
MRI for, 833–835
protein level in, 996–998
renogram for, 1040–1042
total cholesterol level in, 330–333
ultrasonography for, 1145–1147
urine creatinine clearance test and, 482–484
- Glomerulosclerosis, diabetic, 1189
- Gloves, isolation precautions and, 1279
- Glucagon, 654–657
- Glucagonoma
glucagon level in, 655–657
glucose levels in, 658–662
syndromes of, 654
- Glucocorticoid excess, 268–271
- Gluconeogenesis, 464
- Glucose. *See also* Hyperglycemia;
Hypoglycemia
copper and, 461
decreased, PET scan for, 967–970
hemoglobin and, 672
in urine specimen, 1194, 1197
insulin response to, 744–747
levels by age, 657
symptoms of excess, 660
- Glucose intolerance, TG and, 1109–1111
- Glucose metabolism, potassium and, 974–978
- Glucose tolerance test (GTT), 665–669
- Glucose-6-phosphate dehydrogenase (G6PD), 662
- Glucose-6-phosphate dehydrogenase deficiency (G6PDD)
erythrocyte sedimentation rate and, 577–578
sweat chloride values in, 312–314
uric acid level in, 1186–1188
- Glutamic acid, 39–41
- Glutamine, 39–41
- Gamma-glutamyltransferase, 669–672
- Gluten sensitivity
albumin/globulin ratio, 16–18
gliadin antibody in, 116–117
- Gluten-induced enteropathy, 547–550
- Glycated albumin, 631–633
- Glycated hemoglobin A_{1c}, 672–674
- Glycine, 39–41
- Glycogen storage disease
glucose levels in, 659–662
ketone level in, 767–770
total cholesterol level in, 330–333
triglyceride levels and, 1109–1111
- Glycogenolysis, vitamin B₆, 1226–1230
- Glycolysis, PK and, 1020
- Glycoside, cardiac, 595–597
- Goiter
antithyroglobulin/antithyroid peroxidase antibody in, 112–113
iodine-deficiency, 1021–1023, 1114–1116
nontoxic nodular, 215–217
radioactive iodine uptake and, 1021–1023
thyroid scan for, 1090–1092
ultrasonography for, 1167–1168
- Gonadal failure
follicle-stimulating hormone level in, 629–631
luteinizing hormone secretion and, 815–816
- Gonadotropin, human chorionic, 714–717
- Gonadotropin-releasing hormone (GRH), 629–631
- Gonadotropin-secreting pituitary tumor, 629–631
- Gonioscopy, 675–677
- Gonorrhea, 494–497
- Goodpasture's antibody, 99–100
- Goodpasture's syndrome
anti-glomerular basement membrane antibody and, 99–100
kidney biopsy for, 191–194
- Gout, 940–942
arthroscopy of, 147–149
synovial fluid analysis and, 1078–1080
total cholesterol level in, 330–333
triglyceride levels and, 1109–1111
uric acid level in, 1186–1188, 1189–1191
WBC and differential in, 400–403
- Gowns, 1281
- G6PD. *See* Glucose-6-phosphate dehydrogenase *entries*
- Graafian follicle, 629–631
- Graded exercise tolerance test, 594–597
- Graft. *See* Bypass graft
- Graft diameter reduction, 1129–1131
- Graft occlusion, 70–73
- Graft versus host reaction, transfusion related, 1272
- Gram stain, 501, 677–679
- Gram-negative bacteria, 678
- Gram-negative bacterial septicemia, 940–942
- Gram-positive bacteria, 678
- Grand mal seizure, 563–564
- Granular cast, 1195
- Granulocytic leukemia, 1218–1219

- Granuloma
 lung biopsy for, 198–201
 MRI for, 837–839, 859–861
- Granulomatous colitis, 157–159
- Granulomatous disease, mediastinoscopy of, 868–871
- Granulomatous infection
 mediastinoscopy for, 868–871
 platelet count in, 380–382
- Granulomatous skin lesion, 488
- Granulomatous thyroiditis, 215–217
- Graves' disease
 antithyroglobulin/antithyroid peroxidase antibody in, 112–113
 radioactive iodine uptake and, 1021–1023
 thyroglobulin values in, 1087–1088
 thyroid scan for, 1090–1092
 thyroid-binding inhibitory immunoglobulin and, 1089
 thyroid-stimulating hormone and, 1093–1095
 thyroid-stimulating immunoglobulin and, 1096–1097
 total thyroxine level and, 1102–1104
 ultrasonography for, 1167–1168
- Grayish white feces, analysis of, 602–604
- Green feces, analysis of, 602–604
- GRH (gonadotropin-releasing hormone), 629–631
- Gross hemolysis, 762
- Group A streptococcal screen, 680–681
- Group B streptococcus (GBS), culture for, 492, 493, 494
- Growth hormone (GH)
 osteocalcin levels and, 904–905
 phosphorus levels in, 940–942
 stimulation and suppression tests for, 682–684
- Growth pattern, x-ray for, 1027–1029
- Growth plate, x-ray for, 1028–1029
- Growth retardation, intrauterine, 792–795
- Growth spurt, 904–905
- GTT (glucose tolerance test), 665–669
- Guillain-Barre syndrome
 antidiuretic hormone in, 129–130
 electromyography in, 565–567
 electroneurography in, 571–572
- Gynecologic laparoscopy, 785–788
- Gynecological carcinoma, 284–285
- Gynecological ultrasonography, 1155–1158
- Gynecomastia, 589–590
- H**
- Haemophilus*, 509–511
- Haemophilus aegyptius*, 494–497
- Haemophilus influenzae*
 bacterial culture for, 494–497
 bacterial pneumonia and, 502
- Hair, fungal culture of, 514–516
- Hair preparation, 563
- Hairy cell leukemia, 795–797
- Hallucination
 antidepressant toxicity and, 124–128
 quinidine toxicity and, 86–92
- Haloperidol, 131–134
- Hamartoma, 1143–1147
- Ham's test, 683
- Hand
 MRI of, 847
 venipuncture of, 1255
 x-ray of, 1027–1029
- Handwashing, 1279
- Hansen's disease
 angiotensin-converting enzyme in, 82–83
Mycobacterium fortuitum, 488
- Hantavirus, 517–519
- Haptoglobin, 685–687
- Hartnup disease
 amino acid levels in, blood test for, 37–38
 amino acid levels in, urine test for, 40
 5-hydroxyindoleacetic acid level in, 725–726
 vitamin B₁ and, 1228
- Hashimoto's thyroiditis
 antithyroglobulin/antithyroid peroxidase antibody in, 112–113
 radioactive iodine uptake and, 1021–1023
 thyroid-stimulating hormone and, 1093–1095
- HAV (hepatitis A virus), 693–695
- Hay fever
 eosinophil count in, 573–575
 immunoglobulin E level in, 734–735
 immunoglobulin levels in, 27–28
- HBV (hepatitis B virus), 1289–1290
- HCG (human chorionic gonadotropin), 714–717
 quad-marker testing and, 613, 715
 triple-marker testing and, 613, 614, 715
- Hct. *See* Hematocrit
- hCT (calcitonin), 256–259
- HCV. *See* Hepatitis C
- HDLC (high-density lipoprotein cholesterol), 325–329
- HDV (hepatitis D virus), 700
- Head
 CT of, 416–420
 fetal, ultrasonography of, 1134–1139

- Head and neck cancer
 CA 19-9 in, 282-284
 CEA and, 283
 mediastinoscopy and, 868-871
- Head injury
 blood gas analysis in, 226-232
 brain CK-BB and, 474-475
 chloride values in, 307-310
 EEG determining, 563-564
 PET scan for, 963-966
- Headache
 MRI for, 858-861
 visual field test for, 1215-1217
- Healing, fracture
 bone scan for, 245-248
 x-ray for, 1027-1029
- Hearing aid, 1122-1125
- Hearing loss/deafness
 audiometry in, 153-156
 otoscopy for, 905-907
 spondee speech recognition threshold for, 1071-1073
 tuning fork test for, 1122-1125
- Heart
 blood pool imaging and, 237-241
 cardiac scoring of, 421-424
 chest x-ray for enlargement of, 302-303
 cholinesterase in, 1030
 Doppler ultrasound of, 551-554
 electrocardiogram of, 557-561
 exercise stress test for, 594-597
 FDG-PET scan of, 598-601
 MRI of, 844-846
 myocardial perfusion scan of, 888
- Heart disease
 alcohol abuse and, 544-547
 electrocardiogram for, 558-561
 folate deficiency and, 626
 platelet count in, 379-382
 total cholesterol level in, 330-333
 triglyceride levels and, 1109-1111
- Heart failure. *See* Cardiac failure *and* Congestive heart failure
- Heart rate
 ECG and, 557-561
 target, 594-597
- Heart rhythm, 558
- Heart scan, myocardial perfusion, 888-893
- Heart transplant rejection, cyclosporine and, 740-742
- Heart valve function, 558-561
- Heart vessel calcium, CT for, 421
- Heartburn. *See also* Gastroesophageal reflux (GER)
 barium swallow and, 160-162
 EM and, 582-585
- Heat sensitivity, RAIU and, 1081
- Heavy metal poisoning. *See* Metal toxicity
- Heel, venipuncture of, 1253-1254
- Heinz bodies, 364, 392, 1044
- Helical/spiral CT, 412, 416-420, 421
- Helicobacter pylori* antibody, 687-688
- Helicobacter pylori* colonization, 688
- Helicobacter pylori* infection, 688, 1175-1177
- Helmet cell, 364, 392
- Helminth, 733
- Hemangioma
 liver and spleen scan for, 801-803
 MRI for, 848-850
 ultrasonography for, 1129-1131
- Hematemesis, 1172-1174
- Hematocele, 1161-1163
- Hematocrit
 aPTT and, 927
 complete blood count and, 361, 365-367, 367-372
- Hematologic disorders
 CBC and, 368
 Hgb and, 374
 RBC count and, 384
 RBC indices and, 389
 RBC morphology and, 393
 WBC count and, 399
- Hematoma
 abdominal CT of, 404-407
 aPTT in, 926-929
 bilirubin levels in, 163-166
 brain CT of, 417-420
 intravenous pyelography for, 756-758
 kidney CT for, 441-445, 442-445
 liver and spleen scan for, 801-803
 liver/biliary tract CT of, 412-416
 mammography for, 862-864
 MRI for, 840-843
 prothrombin time and, 1008-1011
 splenic CT of, 450-453
 thyroid scan for, 1090-1092
 ultrasonography for, 1129, 1143, 1148, 1162
 voiding cystourethrography for, 527-529
- Hematopoiesis, 1217
- Hematopoietic system
 diagnostic tests for, 1242
 laboratory tests for, 1241-1242
- Hematuria
 aPTT in, 926-929
 prothrombin time and, 1008-1011
- Heme synthesis, 959-960
- Hemochromatosis, 691-693
 ferritin level in, 609-610
 follicle-stimulating hormone level in, 630-631

- glucose levels in, 658–662
- glucose tolerance test for, 666–669
- iron level in, 762–764
- liver biopsy for, 194–197
- total iron-binding capacity and, 765–766
- Hemoconcentration
 - hematocrit in, 369–372
 - hemoglobin in, 374–378
- Hemodialysis
 - aPTT in, 927–929
 - ferritin level in, 609–610
 - lipase levels and, 798
 - magnesium level and, 823–824
 - vitamin C and, 1228
- Hemoglobin
 - complete blood count and, 361, 365–367, 372–378
 - glucose and, 672
 - glycated, 672–674
 - in urine specimen, 1194
 - iron and, 764–765
- Hemoglobin A₂, 689
- Hemoglobin Bart's hydrops fetalis syndrome, 690
- Hemoglobin C crystals, 364, 392
- Hemoglobin C disease
 - erythrocyte sedimentation rate and, 577–578
 - hemoglobin electrophoresis for, 689–691
 - RBC morphology in, 393–396
- Hemoglobin C Harlem anemia, 1060–1061
- Hemoglobin content, 392
- Hemoglobin D, electrophoresis and, 689–691
- Hemoglobin E, 689–690
- Hemoglobin F, 689, 772
- Hemoglobin H disease, 690
- Hemoglobin M, 874
- Hemoglobin S, 689–690, 1060
- Hemoglobinopathy, 1060–1061
 - haptoglobin level in, 686–687
 - hemoglobin in, 374–378
 - osmotic fragility and, 902–903
 - RBC count in, 384–388
- Hemoglobinuria. *See also* Paroxysmal nocturnal hemoglobinuria (PNH)
 - Ham's test for, 1143–1147
 - platelet antibody and, 948–949
- Hemolysis
 - as transfusion reaction, 1272
 - haptoglobin level in, 686–687
 - iron level and, 762
 - magnesium level and, 822–824
 - potassium levels and, 975–978
 - protein level and, 997
 - vitamin B₁₂ and, 1218
- Hemolytic anemia, 457–458
 - acquired, osmotic fragility and, 902–903
 - aldolase levels in, 18–19
 - aspartate aminotransferase levels in, 150–152
 - autoimmune, 357–360, 457–458
 - bilirubin levels in, 164–166
 - bone marrow biopsy for, 174–177
 - cholinesterase enzyme in, 1030–1032
 - chronic, 393–396
 - ferritin level in, 609–610
 - folate level in, 627–628
 - free erythrocyte protoporphyrin test for, 576–577
 - glycated hemoglobin A_{1c} and, 673–674
 - hemosiderin levels in, 692–693
 - human chorionic gonadotropin level in, 716–717
 - iron level in, 762–764
 - lactate dehydrogenase levels in, 775–776
 - microangiopathic, 692–693
 - platelet count in, 379–382
 - RBC count in, 384–388
 - RBC morphology in, 393–396
 - total iron-binding capacity and, 765–766
 - vitamin E and, 1222–1224
- Hemolytic disease, 457–458
- Hemolytic disease of newborn, 902–903
 - carbon dioxide levels in, 280–282
 - DAT and, 459–460
 - hematocrit in, 369–372
 - hemoglobin in, 374–378
 - osmotic fragility and, 902–903
 - platelet count and, 380–382
- Hemolytic jaundice, 163–166
- Hemolytic transfusion reaction, 692–693
- Hemolyzed specimen, 949
- Hemoperitoneum
 - abdominal CT of, 404–407
 - splenic CT of, 450–453
- Hemophilia, 926–929
- Hemophilic arthritis, 1078–1080
- Hemoptysis, 74–77
- Hemorrhage. *See also* Bleeding disorders; Blood loss
 - abdominal laparoscopy and, 783
 - albumin/globulin ratio, 16–18
 - bone marrow biopsy for, 174–177
 - brain CT of, 417–420
 - BUN level in, 1178–1180
 - CT angiography of, 409–412
 - EEG determining, 563–564

- Hemorrhage (*continued*)
fetal-maternal, 773
hematocrit in, 369–372
hemoglobin in, 374–378
lactic acid levels and, 777–779
Meckel's diverticulum scan for, 865–867
MRI for, 833–835, 844–846, 852–854, 855–857, 858–861
pituitary CT of, 438–441
platelet count in, 380–382
proctosigmoidoscopy for, 985–988
radiofrequency ablation and, 1025
RBC count in, 384–388
splenic CT of, 450–453
stereotactic biopsy and, 1075
ultrasonography for, 1155–1158
visual field test for, 1215–1217
- Hemorrhagic cystitis, 518–519
Hemorrhagic fever, 518–519
Hemorrhagic pericarditis, 932–934
Hemorrhoid
colonoscopy for, 347–350
fecal analysis for, 603–604
proctosigmoidoscopy for, 986–988
- Hemosiderin, 691–693, 765
Hemosiderin stain, 691–693
Hemosiderosis, 609–610
Hemostasis, 1008–1011
Hemostatic platelet plug, 617
Hemothorax, 956–958
Hepadnaviridae family, 695
Heparin cofactor assay, 134–136
Heparinization, 1256–1257
Hepatectomy, 135–136
Hepatic. *See also* Liver *entries*
Hepatic abscess
liver/biliary tract CT of, 412–416
MRI of, 833
ultrasonography of, 1148
Hepatic adenoma, ultrasonography of, 1147–1149
Hepatic carcinoma
AFP levels in, 614–617
alanine aminotransferase levels in, 13–15
cancer antigen levels in, 284–285
human chorionic gonadotropin level in, 716–717
lactate dehydrogenase levels in, 775–776
pseudocholinesterase level in, 1012
Hepatic coma
ammonia levels in, 44–45
G6PD levels and, 663
lactic acid levels and, 777–779
Hepatic cyst
abdominal CT of, 404–407
liver/biliary tract CT of, 412–416
Hepatic damage
amino acid levels in, blood test for, 37–38
bilirubin levels in, 164–166
bone marrow biopsy for, 174–177
lactic acid levels and, 777–779
prealbumin and, 983–984
transferrin level in, 1106–1108
vitamin B₁₂ and, 1218–1219
Hepatic disease. *See also* Cirrhosis
AcP levels in, 4
alanine aminotransferase levels in, 13–15
albumin/globulin ratio, 16–18
alcohol abuse and, 544–547
alkaline phosphatase levels in, 24–26
alpha₁-antitrypsin levels in, 138–139
amylase levels in, 52–53
antimitochondrial/antismooth muscle antibody in, 101–102
antineutrophilic cytoplasmic antibodies in, 103–104
apolipoprotein B and, 141–143
aPTT in, 926–929
bleeding time in, 220
blood creatinine clearance test and, 478–479
bone marrow biopsy for, 174–177
BUN level in, 1178–1180
coagulation factors in, 339–341
complement protein levels in, 357–358, 359–360
fibrin degradation product and, 618–619
fibrinogen level in, 620–622
folate level in, 627–628
GGT levels in, 670–672
glucose levels in, 658–662
glucose tolerance test for, 666–669
haptoglobin level in, 686–687
hexosaminidase level in, 705–706
immunoglobulin E level in, 737–738
insulin levels in, 745–747
iron level in, 761
LDLC level in, 327–329
osmotic fragility and, 902–903
plasminogen levels in, 946–947
prealbumin and, 983–984
protein C levels and, 999–1001, 1002–1003
protein level in, 996–998
prothrombin time and, 1008–1011
RBC indices in, 389–391
syphilis serology testing for, 1082–1083
TBG level in, 1098–1099
total cholesterol level in, 331–333

- total iron-binding capacity and, 765–766
- total thyroxine level and, 1102–1104
- triglyceride levels and, 1110–1111
- uric acid level in, 1187–1188
- urine urea nitrogen level in, 1180–1182
- vitamin E and, 1223–1224
- vitamin K and, 1225–1226
- ZZ deficiency in, 137
- Hepatic failure, 1065–1067
 - ammonia levels in, 44–45
 - antithrombin III levels in, 135–136
 - prolactin level in, 991–993
- Hepatic hemangioma, ultrasonography of, 1129–1131
- Hepatic hematoma, ultrasonography of, 1129–1131
- Hepatic injury. *See also* Hepatic damage
 - CT of, 412–416
 - liver and spleen scan of, 800–803
- Hepatic insufficiency, 1085–1086
- Hepatic jaundice, 164–166
- Hepatic metastasis, 1024–1027
- Hepatic necrosis, 40
- Hepatic obstruction
 - apolipoprotein B and, 141–143
 - LDLC level in, 327–329
 - ultrasonography for, 1148–1149
- Hepatic polyp, ultrasonography of, 1148–1149
- Hepatic porphyria, 960–962
- Hepatic transplantation, 135–136
- Hepatic tumor. *See also* Hepatic carcinoma
 - aspartate aminotransferase levels in, 150–152
 - bilirubin levels in, 164–166
 - ultrasonography for, 1148–1149
- Hepatitis
 - AFP levels in, 614–617
 - alanine aminotransferase levels in, 13–15
 - aldolase levels in, 18–19
 - alkaline phosphatase levels in, 24–26
 - amino acid levels in, urine test for, 40
 - antimitochondrial/antismooth muscle antibody in, 101–102
 - antithrombin III levels in, 135–136
 - aspartate aminotransferase levels in, 150–152
 - beta₂-microglobulin levels in, 880–883
 - bilirubin levels in, 164–166
 - complement protein levels in, 357–358
 - cryoglobulin detection in, 485–486
 - GGT levels in, 670–672
 - G6PD levels in, 663
 - HDLC level in, 326–329
 - lactate dehydrogenase levels in, 775–776
 - liver and spleen scan for, 801–803
 - liver biopsy for, 194–197
 - percutaneous transhepatic cholangiography for, 315–318
 - pseudocholinesterase level in, 1012
 - renin value in, 1036–1039
 - rheumatoid factor and, 1049–1050
 - TBG level in, 1098–1099
 - total thyroxine level and, 1102–1104
 - ultrasonography for, 1148–1149
 - vitamin B₁₂ and, 1218–1219
 - WBC and differential in, 400–403
- Hepatitis A antibody, 693–695
- Hepatitis B, 1289–1290
- Hepatitis B antigen/antibody, 695–698
- Hepatitis C, isolation precautions for, 1289–1290
- Hepatitis C antibody, 698–700
- Hepatitis D antibody, 700
- Hepatobiliary scan, 701–704
- Hepatobiliary system
 - diagnostic tests for, 1243–1244
 - laboratory tests for, 1243
- Hepatobiliary system disorders
 - GGT levels in, 670–672
 - natural products affecting, 1275–1276
- Hepatobiliary ultrasonography, 1147–1149
- Hepatoblastoma, 614–617
- Hepatocellular carcinoma, 670–672
- Hepatocellular disorder
 - apolipoprotein A and, 141–143
 - aspartate aminotransferase levels in, 150–152
 - bilirubin levels in, 164–166
 - ferritin level in, 609–610
 - HDLC and LDLC levels in, 326–329
 - immunoglobulin E level in, 737–738
 - pseudocholinesterase level in, 1012
 - ultrasonography for, 1148–1149
- Hepatolenticular degeneration, 268–271
- Hepatoma
 - beta₂-microglobulin levels in, 880–883
 - erythropoietin level in, 581–582
- Hepatomegaly, 1148–1149
- Hepatotoxic drugs, BUN and, 1177–1180
- HER-2 (human epidermal growth factor receptor 2)/neu oncoprotein, in breast cancer, 177, 178
- Herbals, 606
- Hereditary angioedema, 357–358
- Hereditary atransferrinemia, 1106–1108
- Hereditary fructose intolerance. *See* Fructose intolerance

- Hereditary hematologic disorders. *See* Hematologic disorders
- Hereditary hyperoxaluria, 910
- Hereditary hypophosphatemia, 796–797
- Hereditary methemoglobinemia, 874
- Hereditary predispositions, PFTs and, 1012–1017
- Hereditary pyruvate kinase deficiency, 902–903
- Hereditary spherocytosis
bone marrow biopsy for, 174–177
osmotic fragility and, 902–903
RBC morphology in, 393–396
- Hereditary telangiectasia, 220
- Hereditary tyrosinemia. *See* Tyrosinemia
- Hernia
abdominal laparoscopy and, 783
barium swallow for, 160–162
capsule endoscopy for, 274–276
diaphragmatic, 301–303
esophageal manometry for, 583
esophagogastroduodenoscopy for, 586–589
ultrasonography for, 1161–1163
upper GI series for, 1172–1174
- Hernia repair, inguinal, 109–110
- Herniated disk, 446–449, 571–572
electromyography for, 565–567
MRI for, 848–850
- Heroin abuse, 546
- Herpangina, 518–519
- Herpes
Pap smear and, 917
skin biopsy for, 212–214
Tzanck smear in, 212
- Herpes simplex virus (HSV), 517–519
- Heterophil antibody, infectious mononucleosis and, 742–744
- Heterophoria, 750–752
- Heterotopia, 750–752
- Heterozygous biochemical enzyme defect, 709
- Hexacarboxylporphyrin (porphyrin), 959–962. *See also* Porphyrria
- Hexosaminidase A and B, 704–706
- Hexose monophosphate shunt, 663
- Hgb. *See* Hemoglobin
- 5-HIAA (5-Hydroxyindoleacetic acid), 724–726
- Hiatal hernia
barium swallow for, 160–162
capsule endoscopy for, 274–276
esophageal manometry for, 583
esophagogastroduodenoscopy for, 586–589
upper GI series for, 1172–1174
- HICPAC isolation precautions, 1283–1284
- HIDA scan. *See* Hepatobiliary scan
- High altitude
free triiodothyronine levels in, 1112–1113
hematocrit in, 369–372
hemoglobin in, 374–378
hemoglobin levels and, 690
- High-altitude hypoxia, 581–582
- High-density lipoprotein cholesterol, 325–329
- High-fat diet, 767–770. *See also* Fatty diet
ketones and, 767–770
- High-frequency hearing loss, 1071–1073
- High-protein diet, 767–770
- High-risk medications, 1216–1217
- High-stress lifestyle, cardiac scoring and, 421–424
- Hip
arthrogram of, 143–146
MRI of, 847
- Hirschsprung's disease, 157–159
- Hirsutism
DHEAS and, 542–543
testosterone and, 1085–1086
- Histidine, 39–41
- Histoplasma*, 198–201
- Histoplasma capsulatum*, 515–516
- Histoplasmosis
angiotensin-converting enzyme in, 82–83
bronchoscopy for, 250–253
calcium values in, 260–263
mediastinoscopy for, 868–871
platelet count in, 380–382
- HIV. *See* Human immunodeficiency virus (HIV)
- Hodgkin's disease
calcium values in, 260–263
ceruloplasmin levels in, 299–300
copper levels in, 462–463
eosinophil count in, 573–575
ferritin level in, 609–610
fibrinogen level in, 620–622
hemoglobin in, 374–378
LAP levels in, 795–797
liver and spleen scan for, 801–803
lymphangiography for, 819–821
mediastinoscopy for, 868–871
platelet count in, 379–382
RBC count in, 384–388
T-cell enumeration for, 292–293
thoracic CT for, 454–456
WBC and differential in, 400–403
- Holter monitor, 707–709
- Homocysteine, 709–711
- Homocystine, 39–41
- Homocystinuria, 710–711
- Homovanillic acid (HVA), 712–714

- Hookworm infection, 908–909
 D-xylose tolerance test for, 547–550
 immunoglobulin levels in, 27–28
- Hordeolum, 1062–1064
- Hormonal disturbance, 1028–1029
- Hormonal therapy, 179–181
- Hormone, 815
- Horseshoe kidney
 kidney CT of, 442–445
 ultrasonography for, 1145–1147
- Hospital, isolation precautions for, 1277–1283
- Howell-Jolly bodies, 364, 392, 1044
- HP (haptoglobin), 685–687
- HPV (human papillomavirus), 517–519, 915–916
- HSV (herpes simplex virus), 517–519
- HTLV-I/HTLV-II (human T-lymphotropic virus, type I and II), 722–724
- Human chorionic gonadotropin (HCG), 714–717
 quad-marker testing and, 613, 715
 triple-marker testing and, 613, 614, 715
- Human epidermal growth factor receptor 2 (HER-2)/neu oncoprotein, in breast cancer, 177, 178
- Human growth hormone, 682–684
- Human immunodeficiency virus (HIV).
See also Acquired immune deficiency syndrome (AIDS)
 alkaline phosphatase levels in, 25–26
 isolation precautions for, 1289–1290
 syphilis serology testing for, 1081–1083
 tuberculosis and, 487
 type 1 and type 2 antibodies of, 715–717
 viral culture for, 517–519
 WBC and differential in, 400–403
- Human leukocyte antigen (HLA), 879
- Human leukocyte antigen B27, 720–722
- Human papillomavirus (HPV), 517–519, 915–916
- Human T-lymphotropic virus type I and II, 722–724
- Humoral immunity status, immunoglobulins and, 929–931
- Huntington's chorea
 amino acid levels in, blood test for, 37–38
 evoked brain potentials in, 591–594
 FDG-PET scan in, 598–601
 PET scan in, 963–966
- HVA (homovanillic acid), 712–714
- Hyaline casts, 1195, 1196
- Hyaline membrane disease, 946–947
- Hydatidiform mole
 AFP levels in, 615–617
 human chorionic gonadotropin level in, 715–717
 progesterone testing for, 989–990
- Hydration, rapid, 16–18
- Hydrazine exposure, 1228
- Hydrocele, 1161–1163
- Hydrocephalus
 MRI for, 837–839
 ultrasonography for, 1136–1139
- Hydrocephaly, 417–420
- Hydrocortisone, 463
- Hydronephrosis
 intravenous pyelography for, 756–758
 KUB study for, 771–772
 MRI for, 833–835
 retrograde ureteropyelography for, 1045–1048
 ultrasonography for, 1145–1147
- Hydrops fetalis, 930–931
- Hydrosalpinx, 433–437
- 5-Hydroxyindoleacetic acid, 724–726
- Hydroxylstine, 40–41
- Hydroxyproline, 40–41
- Hymenolepis* infection, 908–909
- Hyperactivity, 131–134
- Hyperaldosteronism, 254–255
 adrenal scan in, 5
 aldosterone levels in, 20–22
 magnesium level and, 823–824
 potassium levels and, 976–978, 980–982
 renin value in, 1036–1039
 sodium levels in, 1065–1067
- Hyperalimentation, 823–824
- Hyperalimentation therapy
 BUN level in, 1178–1180
 phosphorus levels in, 940–942
 vitamin levels and, 1229
- Hyperbaric oxygenation, 227–232
- Hypercalcemia
 calcitonin stimulation test for, 257–259
 calcium values in, 260–263
 osmotic concentration and, 900–902
 parathyroid scan for, 923–925
 phosphorus levels in, 940–942
 urinary calcium levels in, 268–271
 vitamin A and, 1227
- Hypercalcemia, infantile, 141–143
- Hypercalciuria, 911–912
- Hypercapnia, 226–232
- Hypercapnic state
 abdominal laparoscopy and, 783
 gynecologic laparoscopy and, 787
- Hyperchromic cell, 394
- Hypereosinophilic syndrome, 573–575

- Hyperfusion, 15–18
- Hypergammaglobulinemia, 84–86
- Hypergastrinemia, 257–259
- Hyperglycemia, 932–934
 - cause and effects of, 658
 - cortisol levels in, 465–467
 - erythrocyte sedimentation rate and, 577–578
 - glucose tolerance test for, 665–669
 - ketone level in, 767–770
 - peritoneal fluid analysis and, 936–938
 - pleural fluid analysis and, 956
 - synovial fluid analysis and, 1078
- Hyperhomocysteinemia, 626
- Hyperhomocystinuria, 709
- Hyperinsulinemic hypoglycemia, 745–747
- Hyperinsulinism, 940–942
- Hyperkalemia
 - electrocardiogram for, 559–561
 - potassium levels and, 976
 - renin value and, 1037
- Hyperlipidemia
 - DHEAS and, 542–543
 - glucose tolerance test for, 666–669
 - type III, uric acid level in, 1186–1188
- Hyperlipoproteinemia, 799–800
 - apolipoprotein B and, 141–143
 - glucagon level in, 655–657
 - LDLC level in, 327–329
 - total cholesterol level in, 330–333
 - triglyceride levels and, 1109–1111
- Hypernatremia
 - osmotic concentration and, 900–902
 - sodium levels in, 1066–1067
- Hyperopia, 1032–1035
- Hyperoxaluria, 910
- Hyperparathyroidism
 - alkaline phosphatase levels in, 24
 - amino acid levels in, urine test for, 40
 - calcium values in, 260
 - chloride values in, 307
 - gastrin stimulation test for, 645
 - ionized calcium values in, 265
 - NT_x for, 345–346
 - parathyroid hormone levels in, 920–922
 - phosphorus levels in, 940–942, 943–945
 - uric acid level in, 1186–1188
 - urinary calcium levels in, 268–271
- Hyperphosphatemia, 261–263, 939
- Hyperpituitarism, 683–684
- Hyperprolactinemia
 - DHEAS and, 542–543
 - follicle-stimulating hormone level in, 630–631
- Hyperpyrexia, 1058–1059
- Hypersensitivity pneumonitis serology, 727
- Hypersensitivity reaction, 174–177
- Hypersplenism
 - haptoglobin level in, 686–687
 - WBC and differential in, 400–403
- Hypertension, 254–255
- Hypertension
 - aldosterone levels in, 20–22
 - cocaine intoxication, 545
 - exercise stress test for, 595–597
 - GGT levels in, 670–672
 - lecithin/sphingomyelin ratio in, 792–795
 - liver and spleen scan for, 801–803
 - lung perfusion scan for, 805–807
 - microalbumin and, 877–879
 - potassium levels and, 976–978
 - renin value in, 1036–1039
 - triglyceride levels and, 1109–1111
 - uric acid level in, 1186–1188
 - vanillylmandelic acid level in, 1203–1205
- Hypertensive retinopathy, 623–625
- Hyperthermia
 - blood gas analysis in, 227–232
 - myoglobin levels in, 894–895
 - phosphorus levels in, 940–942
 - skeletal muscle CK-MM and, 474–475
- Hyperthyroidism
 - angiotensin-converting enzyme in, 83
 - beta₂-microglobulin levels in, 880–883
 - blood creatinine clearance test and, 478–479
 - catecholamine level and, 1203
 - copper levels in, 462–463
 - estradiol level in, 589–590
 - ferritin level in, 609–610
 - free thyroxine level and, 1100–1101
 - free triiodothyronine levels in, 1112–1113
 - GGT levels in, 670–672
 - glucose tolerance test for, 666–669
 - G6PD levels in, 663
 - intrinsic factor antibody and, 759–760
 - LDLC level in, 327–329
 - metanephrine levels and, 872–873
 - osteocalcin levels and, 904–905
 - parathyroid hormone levels in, 921–922
 - protein level in, 996–998
 - pseudocholinesterase level in, 1011–1012
 - radioactive iodine uptake and, 1021–1023
 - TBG level in, 1098–1099
 - testosterone and, 1085–1086

- thyroid-binding inhibitory immunoglobulin and, 1089
- thyroid-stimulating hormone and, 1093–1095
- total cholesterol level in, 331–333
- total thyroxine level and, 1102–1104
- total triiodothyronine levels and, 1114–1116
- triglyceride levels and, 1109–1111, 1110–1111
- urinary calcium levels in, 268–271
- urine urea nitrogen level in, 1180–1182
- vitamin C and, 1228
- Hypertriglyceridemia**
 - apolipoprotein A and, 141–143
 - HDL level in, 326–329
- Hypertrophic anal papillae**, 985–988
- Hypertrophic cardiomyopathy**, 555–557
- Hyperventilation**
 - blood gas analysis in, 227–232
 - chloride values in, 308–310
 - effect on ECG, 560
 - potassium levels and, 975–978
- Hypervolemia**, 16–18
- Hypoalbuminemia**, 261–263
 - radioactive iodine uptake and, 1022–1023
- Hypoaldosteronism**
 - aldosterone levels in, 20–22
 - potassium levels and, 975–978
 - sweat chloride values in, 312–314
- Hypocalcemia**
 - EEG determining, 563–564
 - electrocardiogram for, 559–561
 - electromyography for, 566–567
 - phosphorus levels in, 940–942
 - urinary calcium levels in, 269–271
- Hypocalciuric hypercalcemia**, 269–271
- Hypocholeremic state**, 227–232
- Hypocholehydruria**, 1218–1219
- Hypochromia**, 364, 392
- Hypochromic anemia**, 461–463
 - RBC indices in, 390–391
 - total iron-binding capacity and, 765–766
- Hypochromic cell**, 394
- Hypofibrinogenemia**
 - erythrocyte sedimentation rate and, 577–578
 - prothrombin time and, 1008–1011
- Hypoglycemia**, 932–934
 - catecholamine level and, 1203
 - C-peptide levels in, 468–469
 - EEG determining, 563–564
 - effect on EEG, 563
 - glucagon level in, 655–657
 - peritoneal fluid analysis and, 936–938
 - pleural fluid analysis and, 956
 - prolactin level in, 991–993
 - synovial fluid analysis and, 1078
- Hypogonadism**
 - estradiol level in, 589–590
 - follicle-stimulating hormone level in, 629–631
 - progesterone testing for, 989–990
 - testosterone and, 1085–1086
- Hypokalemia**
 - blood gas analysis and, 227–232
 - electrocardiogram for, 559–561
 - gastric emptying scan for, 643–645
 - myocardial perfusion heart scan and, 890
 - phosphorus levels in, 940–942
 - potassium levels and, 976
 - renin value in, 1036–1039
- Hypokinesia**, 239–241
- Hypolipoproteinemia**
 - LDL level in, 327–329
 - triglyceride levels and, 1110–1111
- Hypomagnesemia**, 261–263
 - gastric emptying scan for, 643–645
 - parathyroid hormone levels in, 921–922
 - potassium levels and, 976–978
- Hyponatremia**, 84–86
 - osmotic concentration and, 900–902
 - renin value in, 1036–1039
 - sodium levels in, 1066–1067
- Hypoparathyroidism**
 - alkaline phosphatase levels in, 24
 - ionized calcium values in, 265–267
 - parathyroid hormone levels in, 921–922
 - phosphorus levels and, 943–945
 - phosphorus levels in, 940–942
 - sweat chloride values in, 311–314
 - uric acid level in, 1186–1188
 - urinary calcium levels in, 269–271
- Hypophosphatemia**, 796–797
- Hypopituitarism**
 - ACTH levels in, 10
 - cortisol levels in, 466–467
 - human growth hormone levels in, 683–684
 - testosterone and, 1085–1086
- Hypoproteinemia**
 - fructosamine level in, 632–633
 - ionized calcium values in, 265–267
 - sodium levels in, 1065–1067
 - sweat chloride values in, 312–314
 - TBG level in, 1098–1099
- Hypoprotrombinemia**, 1225–1226
- Hypotension**
 - catecholamine levels in, 288–290
 - heroin and, 546

- Hypothalamic disorder
 - follicle-stimulating hormone level in, 630–631
 - prolactin level in, 991–993
 - Hypothalamic dysfunction, 815–816
 - Hypothermia
 - as transfusion reaction, 1271
 - effect on EEG, 563
 - heroin and, 546
 - skeletal muscle CK-MM and, 474–475
 - Hypothyroidism, 1093–1095
 - apolipoprotein B and, 141–143
 - bilirubin levels in, 164–166
 - blood gas analysis in, 226–232
 - carbon dioxide levels in, 277–279
 - catecholamine levels in, 287–290
 - copper levels in, 462–463
 - free thyroxine level and, 1100–1101
 - free triiodothyronine levels in, 1112–1113
 - gastrin stimulation test for, 645–647
 - GGT levels in, 670–672
 - glucose tolerance test for, 666–669
 - hyperlipoproteinemia and, 799–800
 - iron level in, 762–764
 - LDLC level in, 327–329
 - magnesium level and, 822–824
 - prolactin level in, 991–993
 - radioactive iodine uptake and, 1021–1023
 - RBC morphology in, 393–396
 - skeletal muscle CK-MM and, 474–475
 - sweat chloride values in, 312–314
 - total cholesterol level in, 330–333
 - total thyroxine level and, 1102–1104
 - total triiodothyronine levels and, 1115–1116
 - urinary calcium levels in, 269–271
 - vitamin A and, 1228
 - Hypoventilation
 - blood gas analysis in, 227–232
 - carbon dioxide levels in, 277–279
 - lung ventilation scan for, 808–810
 - Hypovolemia, 1178–1180
 - Hypoxemia
 - blood gas analysis in, 227–232
 - pulse oximetry for, 1018–1020
 - Hypoxia, 595–597
 - erythropoietin level in, 581–582
 - Holter monitor and, 707–709
 - lactate dehydrogenase levels in, 775–776
 - platelet count in, 380–382
 - RBC count in, 384–388
 - sputum cytology and, 530
 - Hypoxic shock, 474–475
 - Hypoxic state
 - abdominal laparoscopy and, 783
 - gynecologic laparoscopy and, 786
 - Hysteria, 227–232
 - Hysteroqram, 727
 - Hysterosalpinography, 727–730
- I**
- ICSH (interstitial cell-stimulating hormone), 813–816
 - Icteric specimen, 811
 - Idiopathic hypercalcemia
 - calcium values in, 260–263
 - urinary calcium levels in, 268–271
 - Idiopathic inflammatory myopathy, 106–108
 - Idiopathic myxedema, 112–113
 - Idiopathic pulmonary hemosiderosis, 99–100
 - Idiopathic sexual precocity, 1085–1086
 - Idiopathic thrombocytopenic purpura (ITP)
 - G6PD levels in, 663
 - LAP and, 796
 - platelet antibody and, 948–949
 - Ig. *See* Immunoglobulin *entries*
 - Ileal resection, 910–912
 - Ileitis, 1009–1011
 - Imipramine, 124–128
 - Immobilization
 - albumin/globulin ratio, 16–18
 - protein level in, 996–998
 - urinary calcium levels in, 268–271
 - Immune complex disease
 - complement protein levels in, 357–358
 - platelet antibody and, 948–949
 - Immune disorder, 1276
 - Immune system
 - diagnostic tests for, 1245
 - laboratory tests for, 1244–1245
 - Immunocompromised patient
 - cytomegalovirus and, 537
 - isolation precautions and, 1284–1285
 - Immunodeficiency
 - acquired. *See* Acquired immune deficiency syndrome (AIDS)
 - familial, 734–735
 - immunofixation electrophoresis for, 731
 - immunoglobulin E level in, 737
 - lymph node biopsy for, 202–205
 - Immunofixation electrophoresis, 731–733
 - Immunoglobulin A (IgA), 735–738
 - anti-insulin properties of, 748
 - deficiency of, 737, 997
 - gliadin antibodies as, 115–117
 - Immunoglobulin D (IgD), 735–738
 - anti-insulin properties of, 748
 - genetic deficiency of, 737
 - Immunoglobulin E (IgE), 733–735
 - allergen-specific, 26–28

- anti-insulin properties of, 748
- deficiency of, 734
- Immunoglobulin E (IgE) myeloma, 734–735
- Immunoglobulin G (IgG), 113–115, 735–738, 929–931
 - anti-insulin properties of, 748
 - cellular damage and, 457
 - CSF analysis and, 294, 295
 - cytomegalovirus and, 537–538
 - genetic deficiency of, 737
 - gliadin antibodies as, 115–117
 - levels by age, 735–736
 - lupus anticoagulant, 811
 - Lyme disease and, 816
 - mumps and, 883
 - parvovirus B19, 929–931
 - platelet-bound, 948–949
 - rubella, 1051
 - rubeola, 1053
 - varicella, 1206
- Immunoglobulin M (IgM), 113–115, 735–738
 - anti-insulin properties of, 748
 - cytomegalovirus and, 537–538
 - EBV infection and, 742
 - infection and, 883
 - levels by age, 735–736
 - Lyme disease and, 816
 - mumps and, 883
 - parvovirus B19, 929–931
 - platelet-bound, 948–949
 - rubella, 1051
 - rubeola, 1053
 - secondary deficiency of, 737
 - varicella, 1206
- Immunoglobulin-mediated cytotoxic chemical, 733
- Immunoproliferative disorder, 731
- Immunosuppressant, 739–742
- Immunosuppressive therapy, 738
- Impaired glucose tolerance, 1109–1111
- Impaired glucose tolerance test, 665
- Impedance plethysmography, 950–954
- Impotence, 1085–1086
- Inborn enzyme deficiency, 44–45
- Incontinence
 - cystometry for, 520–523
 - sphincter muscle electromyography and, 568–570
 - voiding cystourethrography for, 527–529
- Increased latency, 591
- Indirect antiglobulin testing (IAT), 459–460
- Indirect contact transmission of pathogen, 1277
- Indirect platelet-bound IgG/IgM, 948–949
- Indwelling catheter
 - for bacteria culture, 513
 - for magnesium measurement, 826
 - for microalbumin testing, 878
 - for urinalysis, 1198
 - for urine cytology, 535–536
 - hemosiderin stain and, 692–693
 - osmolality and, 901
 - oxalate levels and, 912
 - porphyrin levels and, 960–962
 - potassium levels and, 981
- Infant. *See also* Child
 - age-specific communication and, 1265
 - amino acid screen in, 39–41
 - aminoacidopathy testing in, 35–38
 - amniotic fluid analysis and, 47–51
 - bilirubin levels in, 164–166
 - binocularity in, 591–594
 - blood gas analysis in, 221–232
 - calcium values in, 259–260
 - carbon dioxide measurement in, 276
 - Chlamydia* antibody testing in, 304–306
 - complement proteins in, 356
 - DAT and, 459–460
 - direct antiglobulin testing (DAT) of, 457–458
 - fibrinogen level in, 620–622
 - gastroesophageal reflux scan in, 648–650
 - glucose levels in, 657
 - haptoglobin level in, 685
 - hearing loss audiometry in, 156
 - hyperphosphatemia in, 939
 - hypoglycemia in, 745
 - idiopathic hypercalcemia, 260
 - metanephrine levels in, 871
 - methemoglobinemia in, 875
 - protein level in, 996
 - radiography of, 1028–1029
 - RBC morphology in, 393–396
 - respiratory distress syndrome in, 791
 - reticulocyte count in, 1042
 - sodium levels in, 1065
 - total CK in, 472
 - vitamin B₁₂ level in, 1217
 - vitamin E deficiency and, 1222–1224
 - vitamin K and, 1225–1226
 - zinc deficiency in, 1234
- Infantile hypercalcemia, 141–143
- Infarct/infarction. *See site-specific entries, e.g.,* Cerebral infarction; Myocardial infarction
- Infarct scan, 750–752
- Infection. *See also specific pathogens*
 - abdominal laparoscopy and, 783
 - adrenal scintiscan for, 5–7
 - amniotic fluid analysis for, 48–51
 - bacterial. *See* Bacterial infection

Infection (*continued*)

- beta₂-microglobulin levels in, 881–883
 - bone marrow biopsy for, 174–177
 - brain CT of, 417–420
 - bronchoscopy for, 250–253
 - ceruloplasmin levels in, 299–300
 - Chlamydia* antibody testing for, 304–306
 - colonoscopy for, 347–350
 - colposcopy for, 353–355
 - complement protein levels in, 357–358, 359–360
 - copper levels in, 462–463
 - CRP assay for, 470–472
 - cryoglobulin detection in, 485–486
 - cystoscopy for, 524–526
 - echocardiography for, 551–554
 - eosinophil count in, 573–575
 - erythrocyte sedimentation rate and, 577–578
 - FDG-PET scan for, 599–601
 - ferritin level in, 609–610
 - fungal. *See* Fungal infection
 - gallium scan for, 636–638
 - genital, 916–919
 - glucagon level in, 655–657
 - glucose tolerance test for, 666–669
 - haptoglobin level in, 686–687
 - hearing loss audiometry for, 154–156
 - immunoglobulin E level in, 737–738
 - infertility and, 109–110
 - iron level in, 762–764
 - isolation precautions for, 1277–1284
 - liver and spleen scan for, 801–803
 - lung biopsy for, 198–201
 - lymph node biopsy for, 202–205
 - MRI for, 833–835, 848–850, 855–857
 - parasitic. *See* Parasitic infection
 - peritoneal fluid analysis for, 935–938
 - platelet count in, 380–382
 - pseudocholinesterase level in, 1011–1012
 - radiography for, 1028–1029
 - slit-lamp biomicroscopy for, 1062–1064
 - stereotactic biopsy and, 1075
 - sweat chloride values in, 311–314
 - total iron-binding capacity and, 765–766
 - transferrin level in, 1106–1108
 - ultrasonography for, 1150–1152, 1156–1158, 1164–1166
 - viral. *See* Viral infection
 - vitamin A and, 1228
 - WBC and differential in, 399–403
 - white blood cell scan for, 1231–1233
 - zinc level in, 1235–1236
- Infectious diarrhea, 603–604
 - Infectious disease. *See also specific diseases, e.g.,* Tuberculosis
 - cardiolipin antibody in, 114
 - gallium scan for, 636–638
 - renogram for, 1040–1042
 - sputum cytology for, 530–534
 - WBC and differential in, 400–403
 - white blood cell scan for, 1231–1233
 - Infectious enteritis, 274–276
 - Infectious hepatitis. *See also* Hepatitis
 - pseudocholinesterase level in, 1012
 - TBG level in, 1098–1099
 - Infectious mononucleosis
 - alanine aminotransferase levels in, 13–15
 - alkaline phosphatase levels in, 24–26
 - antimitochondrial/antismooth muscle antibody in, 101–102
 - bilirubin levels in, 164–166
 - bone marrow biopsy for, 174–177
 - cold agglutinin titer levels in, 342–343
 - cryoglobulin detection in, 485–486
 - EBV-specific serology in, 742–744
 - GGT levels in, 670–672
 - lymph node biopsy for, 202–205
 - rheumatoid factor and, 1049–1050
 - screening for, 742–744
 - syphilis serology testing for, 1081–1083
 - viral culture for, 518–519
 - WBC and differential in, 400–403
 - Infectious process, 174–177
 - Infectious pulmonary disease, 951–954
 - Infertility. *See also* Fertility study
 - antisperm antibodies and, 108–110
 - Chlamydia* antibody testing for, 304–306
 - semen analysis for, 1057–1059
 - uterine fibroid embolization and, 1199
 - Infiltrating lobular carcinoma, 1143–1147
 - Inflammation
 - abdominal angiography of, 58–61
 - bronchoscopy for, 250–253
 - colonoscopy for, 347–350
 - colposcopy for, 353–355
 - copper levels in, 462–463
 - cortisol and, 464
 - CRP assay for, 470–472
 - cystoscopy for, 524–526
 - exercise stress test for, 595–597
 - fibrinogen level in, 620–622
 - fluorescein angiography for, 623–625
 - gallium scan for, 636–638
 - LAP levels in, 795–797
 - lipase levels in, 797–799

- liver and spleen scan for, 801–803
- MRI for, 833–835, 855–857
- mumps and, 883
- percutaneous transhepatic cholangiography for, 315–318
- prealbumin and, 983–984
- RBC morphology in, 393–396
- renal angiography in, 79–82
- ultrasonography for, 1148–1149
- upper GI series for, 1172–1174
- white blood cell scan for, 1231–1233
- Inflammatory bowel disease. *See also*
 - Crohn's disease; Ulcerative colitis
 - antineutrophilic cytoplasmic antibodies in, 103–104
 - cancer antigen levels in, 284–285
 - CRP assay for, 470–472
 - fecal analysis for, 603–604
 - gastrointestinal blood loss scan, 651–654
 - immunoglobulin E level in, 737–738
 - vitamin B₁₂ and, 1218–1219
 - vitamin D and, 1220–1222
 - white blood cell scan for, 1231–1233
- Inflammatory disease, 712–714
 - alpha₁-antitrypsin levels in, 138–139
 - CRP assay for, 470–472
 - erythrocyte sedimentation rate and, 577–578
 - ferritin level in, 609–610
 - gallium scan for, 636–638
 - haptoglobin level in, 686–687
 - pulmonary angiography of, 74–77
 - RBC count in, 384–388
 - renogram for, 1040–1042
 - sputum cytology for, 530–534
 - urine cytology for, 534–536
 - WBC and differential in, 399–403
- Influenza, WBC and differential in, 400–403
- Inguinal hernia repair, 109–110
- inhibin-A, dimeric, 614
- Injury, 1028–1029
- Inner ear malformation, 154–156
- INR (International normalized ratio), 1007–1011
- Insecticide exposure
 - pseudocholinesterase level in, 1012
 - RBC cholinesterase and, 1030–1032
- Inspiratory capacity, 1013
- Inspiratory pressure, 1012–1017
- Inspiratory reserve volume, 1013
- Insulin
 - antibody formation, 748–749
 - cortisol and, 464
 - glucose and, 744–747
 - potassium levels and, 975–978
- Insulin C-peptide, 467
- Insulin-dependent diabetes (type 1). *See also* Diabetes mellitus
 - C-peptide levels in, 468
 - insulin levels in, 745
 - intrinsic factor antibody and, 759
- Insulin-induced hypoglycemia, 991–993
- Insulinoma, 659–662
- Insulin-resistant diabetes, 745
- Intact parathyroid hormone, 919–922
- Intermittent porphyria, acute. *See* Acute intermittent porphyria
- Internal bleeding, 833–835
- Internal scarring, 728–730
- International normalized ratio (INR), 1007–1011
- International Sensitivity Index (ISI), 1007
- Interstitial cell-stimulating hormone (ICSH), 813–816
- Interstitial pulmonary disease, 250–253
- Intervertebral disk, herniated, 446–449, 571–572
 - electromyography for, 565–567
 - MRI for, 848–850
- Intestinal atresia, ultrasonography for, 1136–1139
- Intestinal biopsy, 188–190
- Intestinal disease
 - glucose tolerance test in, 666–669
 - oxalate levels in, 910–912
 - proctosigmoidoscopy in, 985–988
- Intestinal distention, colonoscopy in, 347–350
- Intestinal fistula, potassium levels and, 976–978
- Intestinal infection
 - colonoscopy in, 347
 - proctosigmoidoscopy in, 985–988
- Intestinal inflammation. *See* Crohn's disease; Colitis; Enteritis; Inflammatory bowel disease; Ulcerative colitis
- Intestinal lymphangiectasia, triglyceride levels in, 1110–1111
- Intestinal malabsorption, vitamin B₁₂ in, 1218–1219
- Intestinal obstruction
 - abdominal laparoscopy and, 783
 - KUB study for, 771–772
 - upper GI series and, 1173
- Intestinal perforation. *See* Perforated bowel
- Intestinal resection
 - D-xylose tolerance test and, 547–550
 - vitamin D and, 1220–1222
- Intoxication, alcohol, 544–547
- Intra-abdominal bleeding, 782–785
 - abdominal laparoscopy and, 783
- Intra-aortic balloon pump, chest x-ray and, 301–303

- Intracellular parasite, 364, 392
- Intracerebral hematoma, 417–420
- Intracranial pressure
brain CT of, 417–420
EEG determining, 562–564, 563–564
- Intraepithelial lesion/malignancy, 915
- Intrahepatic abscess, 1148–1149
- Intrahepatic biliary hypoplasia, 24–26
- Intramural hematoma, 844–846
- Intraocular muscle function, 750–752
- Intraocular pressure (IOP), 752–755
- Intraparenchymal hematoma, 837–839
- Intrarenal hematoma, 79–82
- Intrauterine device
immunoglobulin E level in, 737–738
MRI and, 833, 837, 841, 844, 848, 852, 856, 859
placement of, ultrasonography for, 1156–1158
- Intrauterine fetal death
AFP levels in, 614
fibrin degradation product and, 618–619
human chorionic gonadotropin level in, 716–717
- Intrauterine growth retardation, 792–795
- Intravascular coagulation. *See*
Disseminated intravascular coagulation (DIC)
- Intravenous device, chest x-ray and, 301–303
- Intravenous glucose infusion, 1066–1067
- Intravenous overload, 374–378
- Intravenous pyelography, 755–758
- Intravenous therapy
potassium levels and, 976–978
sodium levels and, 1065–1067
- Intrinsic factor antibody, 759–760
- Intrinsic factor deficiency, 1218–1219
- Intussusception, 157–159
- Invasive carcinoma, 353–355
- In-vivo antibody sensitization, 457–458
- Iodinated dye(s)
angiography and, 59, 63, 67, 71, 74, 79
hysterosalpingography and, 728
intravenous pyelography and, 756
voiding cystourethrography and, 527
- Iodine, excessive intake of, 1102–1104
- Iodine uptake, 1021–1023
- Iodine-deficiency goiter
radioactive iodine uptake and, 1021–1023
total triiodothyronine levels and, 1114–1116
- Iodine-rich food product, 1022
- IOM function, 750–752
- Ion, 974
- Ionized calcium, 264–267
- Ionizing radiation, 874
- Iridocorneal endothelial syndrome, 676–677
- Iritis, 1062–1064
- Iron (Fe), 609–610, 760–764
ferritin and, 608
hemosiderin and, 691
transferrin and, 1106
- Iron overload, transfusion related, 1272
- Iron saturation, 764–766
- Iron stain, 691
- Iron storage granule, 691
- Iron-binding capacity, total, 764–766
- Iron-deficiency anemia
copper levels in, 462–463
ferritin level in, 609–610
free erythrocyte protoporphyrin test for, 576–577
iron level with, 762–764
osmotic fragility and, 902–903
platelet count in, 379–382
RBC indices in, 390–391
RBC morphology in, 393–396
total iron-binding capacity and, 765–766
transferrin level in, 1106–1108
- Irrigation, venipuncture and, 1256–1257
- Ischemia
electrocardiogram for, 558–561
exercise stress test for, 595–597
Holter monitor and, 707–709
MRI for, 843–846
PET scan for, 967–970
plethysmography for, 950–954
transesophageal echocardiography of, 555–557
ultrasonography for, 1129–1131
- Ischemic heart disease
myocardial perfusion heart scan for, 888–893
total cholesterol level in, 330–333
triglyceride levels and, 1109–1111
- ISI (International Sensitivity Index), 1007
- Islet cell tumor
C-peptide levels in, 468–469
glucose tolerance test for, 666–669
MRI for, 852–854
- Isoenzyme
alkaline phosphatase and, 23–26
creatine kinase and, 472–475
lactate dehydrogenase and, 775–776
- Isoflow volume, 1014
- Isolation precautions
for hospitals, 1277–1283
of HICPAC, 1283–1284
- Isopropyl alcohol, 767–770
- Isospora belli* infection, 908–909

Isotope Dilution Mass Spectrometry (IDMS), 481

IV. *See* Intravenous *entries*

J

Jaundice

- bilirubin levels in, 163–166
- CT in, 413, 430
- ERCP in, 322
- GGT levels in, 670
- hemolytic, 163–166
- hepatic, 164–166
- hepatitis A virus and, 693
- lactate dehydrogenase levels in, 775–776
- laparoscopic evaluation of, 782
- liver-spleen scan in, 801
- obstructive, 670, 775, 1225
- percutaneous transhepatic cholangiography for, 315–318
- prehepatic, 163–166
- ultrasonography for, 1148
- vitamin K and, 1225–1226

Jejunal shunt, 910–912

Jo-1 antibody, 104–108

Joint(s). *See also* Arthritis; Rheumatoid arthritis

- degenerative disease of, 147–149, 1078–1080
- derangement/dislocation of
 - arthrogram in, 144–146
 - radiography in, 1028–1029
- effusion in, radiography for, 1028–1029
- MRI of, 847–850
- pain in
 - arthroscopy for, 146
 - bone scan for, 246
 - Lyme disease and, 816
- tumor of
 - arthroscopy for, 147–149
 - synovial fluid analysis in, 1078–1080

Joint fluid analysis, 1077–1080

Juvenile dermatomyositis, 357–358

Juvenile rheumatoid arthritis, 721–722

K

Kallmann's syndrome, 815–816

Karyotype

- amniotic fluid analysis and, 48
- chorionic villus biopsy for, 185

Kawasaki disease, 254–255

Keloid, 212–214

Keratitis, 517–519

Keratocoma, 1062–1064

Keratoplasty, 913–914

Ketamine, 672

Ketoacid(s)

- amino acids and, 1004
- carbon dioxide levels and, 278–279

Ketoacidosis, 84–86

- alcoholism and, ketones in, 767–770
- BUN level in, 1178–1180
- chloride values in, 308–310
- diabetic. *See* Diabetic ketoacidosis
- phosphorus levels in, 939–942
- potassium levels and, 975–978, 980–982
- uric acid and, 1189

Ketoconazole, 543

Ketone body

- in blood and urine, 767–770
- in urine specimen, 1194, 1197

Ketonuria, 767

17-Ketosteroid, 542

Ki67, in breast cancer, 177, 178

Kidney. *See also* Renal *entries and citations*

- beginning with* Nephroangiography of, 78–82
- biopsy of, 191–194
- computed tomography of, 412–416, 441–445
- C-peptide and, 468
- cystoscopy and, 523
- electrolyte balance and, 1068
- erythropoietin and, 580
- intravenous pyelography of, 755–758
- ultrasonography of, 1144–1147
- UTI spreading to, 521

Kidney stones. *See* Renal calculi

Kidney, ureter, and bladder (KUB) study, 770–772

Klebsiella, 494–497, 512–514

Klebsiella pneumoniae, 502

Kleihauer-Betke test, 772–774

Klinefelter's syndrome

- follicle-stimulating hormone level in, 629–631
- testosterone and, 1085–1086

Knee

- analysis of fluid from, 1077
- meniscal tear in
 - arthrography and, 144
 - MRI of, 848

KUB (kidney, ureter, and bladder) study, 770–772

Kwashiorkor, 762–764

L

Laboratory test(s)

- for auditory system, 1237
- for cardiovascular system, 1237
- for drug therapy monitoring and toxicology, 1249–1250
- for endocrine system, 1238–1239

- Laboratory test(s) (*continued*)
- for gastrointestinal system, 1239–1240
 - for genitourinary system, 1240–1241
 - for hematopoietic system, 1241–1242
 - for hepatobiliary system, 1243
 - for immune system, 1244–1245
 - for musculoskeletal system, 1246
 - for nutritional consideration, 1247
 - for ocular system, 1247
 - for reproductive system, 1248
 - for respiratory system, 1249
 - natural products affecting, 1274–1276
 - nursing diagnoses associated with, 1264
 - patient preparation for, 1251
- Laceration, splenic, CT of, 404, 450
- Lactase, 779
- Lactate dehydrogenase, 775–776
- Lactation
- magnesium level and, 823–824
 - vitamin B₆ and, 1228
- Lactic acid, 776–779
- Lactic acidosis, 84–86
- lactic acid levels and, 777–779
 - phosphorus levels in, 940–942
 - sodium levels in, 1065–1067
 - uric acid level in, 1186–1188
- Lactogenic hormone, 990
- Lactose, 779
- Lactose intolerance, 780
- amino acid levels in, urine test for, 40
 - intestinal biopsy for, 188–190
- Lactose tolerance test, 779–781
- LAP (leukocyte alkaline phosphatase), 795–797
- Laparoscopy
- abdominal, 782–785
 - gynecologic, 785–788
- Laron dwarfism, 683–684
- Laryngospasm, 555
- Laser ablation, 917
- LASIK surgery, 913
- Lassa virus, 518–519
- Latex allergy, 27–28, 789
- Laxative abuse
- aldosterone levels in, 20–22
 - magnesium level and, 823–824
 - potassium levels and, 976–978
- LDLC (low-density lipoprotein cholesterol), 325–329
- Lead, 789–791
- Lead encephalopathy, 790
- Lead mobilization test, 790–791
- Lead poisoning
- D-aminolevulinic acid levels in, 41–43
 - free erythrocyte protoporphyrin test for, 576–577
 - uric acid level in, 1186–1188, 1189–1191
- Lecithin/sphingomyelin ratio, 791–795
- LEEP procedure, 182–185
- Left atrial hypertension, 805–807
- Left bundle branch block, 595–597
- Left ventricle aneurysm, 886
- Left ventricle enlargement/hypertrophy myocardial perfusion heart scan for, 890
- natriuretic peptide in, 254
 - PET scan for, 967–970
- Legg-Calvé-Perthes disease
- bone scan for, 245–248
 - MRI for, 848–850
- Legionella* spp.
- culture for, 502, 512–514
 - lung biopsy for, 198–201
- Leiomyoma, 1156–1158
- Leishmaniasis, 1049–1050
- Lens disorders, 676–677
- Leprosy, 261–263
- angiotensin-converting enzyme in, 82–83
 - Mycobacterium fortuitum*, 488
 - protein level in, 996–998
 - rheumatoid factor and, 1049–1050
 - syphilis serology testing for, 1081–1083
- Leptospirosis, 1081–1083
- Lesch-Nyhan syndrome, 1186–1188
- Leucine, 40–41
- Leucine crystal, 1196
- Leukemia
- aldolase levels in, 18–19
 - amino acid levels in, urine test for, 40
 - beta₂-microglobulin levels in, 880–883
 - bone marrow biopsy for, 174–177
 - calcium values in, 260–263
 - ceruloplasmin levels in, 299–300
 - chronic granulocytic, 1218–1219
 - copper levels in, 462–463
 - cryoglobulin detection in, 485–486
 - ferritin level in, 609–610
 - hemoglobin electrophoresis and, 689–691
 - hemoglobin in, 374–378
 - human T-lymphotropic virus antibodies and, 722–724
 - immunoglobulin E level in, 737–738
 - lactate dehydrogenase levels in, 775–776
 - LAP levels in, 795–797
 - lymph node biopsy for, 202–205
 - platelet antibody and, 948–949
 - platelet count in, 379–382
 - pyruvate kinase levels in, 1020

- RBC count in, 384–388
- RBC morphology in, 393–396
- Schirmer tear test for, 1055–1056
- uric acid level in, 1189–1191
- urinary calcium levels in, 268–271
- urine creatinine clearance test and, 482–484
- vitamin B₁₂ and, 1218–1219
- WBC and differential in, 399–403
- Leukemoid drug reaction, 174–177
- Leukocyte, 1195
- Leukocyte alkaline phosphatase (LAP), 795–797
- Leukocytoclastic skin vasculitis, 103–104
- Leukocytosis, 397, 398
 - potassium levels and, 975–978
 - vitamin B₁₂ and, 1218–1219
- Leukopenia, 397, 400–403
- Leukoplakia, 353–355
- Leydig cell, 1084
- LH (luteinizing hormone), 814–816
- Licorice, excessive ingestion of, 976–978
- Lidocaine, 86–92
- Lifestyle
 - cardiac scoring for, 421–424
 - creatine kinase and, 474–475
- Ligament
 - arthrogram of, 143–146
 - arthroscopy of, 147–149
- Light, as source of interference with
 - pulse oximetry, 1019
- Limb girdle muscular dystrophy, 18–19
- Linen and laundry, 1282
- Lipase, 797–799
- Lipemic specimen, 811
- Lipid emulsion therapy, 1019
- Lipid metabolism, 140–143
- Lipoid ovarian tumor, 989–990
- Lipoid pneumonia, 530–534
- Lipoma, 837–839
- Lipoprotein deficiency, 141–143
- Lipoprotein electrophoresis, 799–800
- Listeria*, 494–497
- Lithium, 131–134
 - thyroid antibody levels in, 112–113
 - thyroid-stimulating immunoglobulin and, 1096–1097
- Liver
 - cholinesterase in, 1030
 - computed tomography of, 412–416
 - C-reactive protein and, 470–472
 - iron storage in, 764–765
 - lactic acid in, 776–779
 - MRI of, 832–835
 - prealbumin and, 983–984
 - protein C and, 999
 - protein synthesizing/catabolizing in, 1004
 - radiofrequency ablation of, 1024–1027
 - transferrin formation in, 1106–1108
 - trauma to, KUB study for, 771–772
 - ultrasonography of, 1147–1149
- Liver and spleen scan, 800–803
- Liver biopsy, 194–197
- Loffler's syndrome, 573–575
- Long-acting thyroid stimulator, 1095
- Loop electrosurgical excision procedure (LEEP), 917
- Loose body, 147–149
- Lordosis, 1016–1017
- Low birth weight, 615–617
- Low-density lipoprotein cholesterol (LDLC), 325–329
- Lower abdominal ultrasound, 1155–1158
- Lower endoscopy, 346–350
- Lower gastrointestinal cancer, 737–738
- Lower limb venography, 1207
- Lower motor neuron, 565–567
- Lower panendoscopy, 346–350
- Lowe's syndrome, 40
- Lumbar spondylosis, 446–449
- Lumpectomy, 840
- Lung. *See also* Pulmonary *entries*
 - acetylcholinesterase in, 1030
 - chest x-ray of, 301–303
 - displacement of, 805–807
 - hyperinflation of, 555–557
 - injury to, transfusion-related, 1270–1271
- Lung biopsy, 197–201
- Lung cancer
 - alkaline phosphatase levels in, 24–26
 - beta₂-microglobulin levels in, 880–883
 - bronchoscopy for, 250
 - calcitonin stimulation test for, 257–259
 - calcium values in, 261–263
 - ceruloplasmin levels in, 299–300
 - cortisol levels in, 465–467
 - FDG-PET scan for, 599–601
 - human chorionic gonadotropin level in, 716–717
 - pulmonary function study in, 1012–1017
 - sputum cytology for, 530–534
- Lung CK-BB, 473–474
- Lung perfusion scan, 804–807
- Lung perfusion scintigraphy, 804–807
- Lung scintiscan, 804–807
- Lung ventilation scan, 807–810
- Lung volume, 1012–1017
- Lupoid hepatitis, 106–108
- Lupus anticoagulant antibody (LA), 811–813

- Lupus erythematosus
 discoid, 212–214
 disseminated, 191–194, 400–403
 systemic. *See* Systemic lupus erythematosus (SLE)
- Luteinizing hormone (LH), 813–816
- Luteotropic hormone, 990
- Luteotropin, 813
- Lycine, 40–41
- Lyme antibody, 816–818
- Lyme disease, 816, 1082–1083
- Lymph node
 biopsy of, 202–205
 chest x-ray for enlargement of, 302–303
 infectious mononucleosis and, 742–744
 thoracic CT for, 454–456
 ultrasonography of, 1150–1152, 1164–1166
- Lymphadenoma, 175–177
- Lymphangiography, 818–821
- Lymphangitis, 202–205
- Lymphatic disease, 1164–1166
- Lymphatic fistula, 16–18
- Lymphatic leukemia, 174–177
- Lymphatic system, 818–821
- Lymphatic vessel, abnormal, 819–821
- Lymphoblastic leukemia
 human T-lymphotropic virus antibodies and, 722–724
 LAP levels in, 795–797
- Lymphocytes, 291–293, 398
- Lymphocytic choriomeningitis virus, 518–519
- Lymphocytic leukemia
 beta₂-microglobulin and, 879
 cryoglobulin detection in, 485–486
 WBC and differential in, 400–403
- Lymphocytopenia, 400–403
- Lymphogranuloma venereum
 lymph node biopsy for, 202–205
 Pap smear and, 917
 syphilis serology testing for, 1081–1083
- Lymphoma. *See also specific types, e.g.,*
 Hodgkin's disease
 beta₂-microglobulin levels in, 880–883
 bone marrow biopsy for, 174–177
 calcium values in, 260–263
 cryoglobulin detection in, 485–486
 D-xylose tolerance test for, 547–550
 erythrocyte sedimentation rate and, 577–578
 FDG-PET scan for, 599–601
 gallium scan for, 636–638
 immunoglobulin E level in, 737–738
 lymph node biopsy for, 202–205
 lymphangiography for, 819–821
 platelet count in, 379–382, 380–382
 RBC morphology in, 393–396
 Schirmer tear test for, 1055–1056
 ultrasonography for, 1150–1152
 urinary calcium levels in, 268–271
 vitamin D and, 1220–1222
 WBC and differential in, 400–403
- Lymphosarcoma
 bone marrow biopsy for, 174–177
 erythrocyte sedimentation rate and, 577–578
 uric acid level in, 1189–1191
- M**
- MAA (macroaggregated albumin), 804–807
- Macroadenoma, 858–861
- Macroaggregated albumin (MAA), 804–807
- Macroamylasemia, 52–53
- Macro-CK, 473–474
- Macrocyte, 363, 392
- Macrocytic anemia, 389–391
- Macroglobulin, 738
- Macroglobulinemia, 174–177. *See also*
 Waldenström's macroglobulinemia
- Macrophage, 734
- Macular degeneration
 fluorescein angiography for, 623–625
 fundus photography for, 634–635
 visual field test for, 1215–1217
- Macular drusen, 1215–1217
- Magnesium
 in blood specimen, 822–824
 in urine specimen, 825–828
- Magnesium deficiency, 823–824
 alkaline phosphatase levels in, 25–26
 ionized calcium values in, 265–267
- Magnetic resonance angiography (MRA), 829–831, 836–839
 of pancreas, 851
 of pelvis, 855
- Magnetic resonance imaging (MRI)
 of abdomen, 832–835
 of brain, 836–839
 of breast, 839–843
 of chest, 843–846
 of musculoskeletal system, 847–850
 of pancreas, 851–854
 of pelvis, 854–857
 of pituitary area, 858–861
- Major depression, 126–128
- Major histocompatibility complex, 720
- Malabsorption
 albumin/globulin ratio, 16–18
 amino acid levels in, blood test for, 37–38
 aPTT in, 926–929

- copper levels in, 462–463
- D-xylose tolerance test for, 547–550
- folate level in, 627–628
- magnesium level and, 823–824
- potassium levels and, 976–978
- protein level in, 996–998
- radioactive iodine uptake and, 1022–1023
- total cholesterol level in, 331–333
- urinary calcium levels in, 269–271
- vitamin B₆ and, 1227, 1228
- vitamin C and, 1228
- zinc level in, 1235–1236
- Malabsorption syndrome
 - BUN level in, 1178–1180
 - fecal analysis for, 603–604
 - fecal fat and, 605
 - gastric emptying scan for, 642–645
 - glucose levels in, 659–662
 - phosphorus levels in, 940–942
 - sodium levels and, 1068–1071
 - triglyceride levels and, 1110–1111
 - vitamin B₁₂ and, 1218–1219
 - vitamin C and, 1227
 - vitamin D and, 1220–1222
 - vitamin E and, 1222–1224
- Malaria
 - bacterial culture for, 498–501
 - cold agglutinin titer levels in, 342–343
 - osmotic fragility and, 902–903
 - platelet count in, 380–382
 - rheumatoid factor and, 1049–1050
 - syphilis serology testing for, 1081–1083
 - WBC and differential in, 400–403
- Malignancy. *See also particular types and site-specific entries*
 - abdominal laparoscopy and, 783
 - AFP levels in, 614
 - alkaline phosphatase levels in, 24–26
 - barium enema for, 157–159
 - beta₂-microglobulin levels in, 880–883
 - bronchoscopy for, 250–253
 - calcitonin stimulation test for, 257–259
 - calcium values in, 261–263
 - ceruloplasmin levels in, 299–300
 - colonoscopy for, 426–429
 - complement protein levels in, 359–360
 - copper levels in, 462–463
 - cystoscopy for, 523–526
 - eosinophil count in, 573–575
 - fibrinogen level in, 620–622
 - haptoglobin level in, 686–687
 - immunoglobulin E level in, 737–738
 - intestinal biopsy for, 188–190
 - kidney biopsy for, 191
 - liver and spleen scan for, 801–803
 - liver biopsy for, 194–197
 - liver/biliary tract CT of, 412–416
 - lung biopsy for, 198–201
 - lymph node biopsy for, 202–205
 - MRI for, 855–857
 - pericardial fluid analysis for, 932–934
 - peritoneal fluid analysis for, 935–938
 - platelet count in, 379–382
 - pleural fluid analysis and, 956–958
 - protein levels in, 1004–1006
 - syphilis serology testing for, 1082–1083
 - thyroid scan for, 1090–1092
 - transferrin level in, 1106–1108
 - ultrasonography for, 1140–1141, 1143–1147, 1162–1163
 - urine cytology for, 534–536
 - urine markers for, 218–219
 - vitamin C and, 1228
 - WBC and differential in, 399–403
- Malignant hypertension, 1036–1039
- Malignant hyperthermia
 - myoglobin levels in, 894–895
 - skeletal muscle CK-MM and, 474–475
- Malignant melanoma, 212–214
- Malignant ocular neoplasm in angle, 676–677
- Mallory-Weiss syndrome
 - capsule endoscopy for, 274–276
 - esophagogastroduodenoscopy for, 586–589
 - fecal analysis for, 603–604
- Malnutrition, 261–263. *See also* Starvation
 - albumin/globulin ratio, 16–18
 - alpha₁-antitrypsin levels in, 138–139
 - amino acid levels in, blood test for, 37–38
 - apolipoprotein B and, 141–143
 - calcitonin stimulation test for, 257–259
 - ceruloplasmin levels in, 299–300
 - copper levels in, 462–463
 - fecal fat and, 606–608
 - folate level in, 627–628
 - free triiodothyronine levels in, 1112–1113
 - hematocrit in, 369–372
 - hemoglobin in, 374–378
 - human growth hormone levels in, 683–684
 - iron level in, 762–764
 - lecithin/sphingomyelin ratio in, 792–795
 - luteinizing hormone secretion and, 815–816
 - phosphorus levels in, 940–942
 - prealbumin and, 983–984

- Malnutrition (*continued*)
 protein level in, 996–998
 pseudocholinesterase level in, 1012
 radiography for, 1028–1029
 RBC count in, 384–388
 RBC indices in, 389–391
 TBG level in, 1098–1099
 testosterone and, 1085–1086
 total cholesterol level in, 330–333,
 331–333
 transferrin level in, 1106–1108
 triglyceride levels and, 1110–1111
 vitamin B₆ and, 1227, 1228
 WBC and differential in, 400–403
 zinc level in, 1234–1236
- Mammography, 861–864
 MRI and, 840
 stereotactic biopsy and, 1074
 ultrasonography and, 1142
- Man
 follicle-stimulating hormone level in,
 628
 prolactin level in, 990
- Manic depression, 131–134, 287–290
- Manometry
 esophageal, 582–585
- Mantoux test, 301–303, 1119, 1121
- Maple syrup urine disease
 amino acid levels in, urine test for, 40
 glucose levels in, 659–662
- Marburg virus, 518–519
- Masculinization, 542
- Masks, 1280–1281
- Mass
 MRI for, 833–835, 855–857
 PET scan for, 963–966
 renogram for, 1040–1042
 ultrasonography for, 1156–1158,
 1161–1163, 1164–1166
- Mast cell, 733
- Mastectomy, 840
- Mastitis, 862–864
- Mastocytosis, 725–726
- Maternal diabetes, 792–795
- Maximal inspiratory-expiratory pressure,
 1014
- Maximal midexpiratory flow, 1013
- Maximal voluntary ventilation, 1013–1017
- May-Hegglin anomaly, platelet count
 and, 380–382
- MB (myoglobin), 764–765, 893–895
- MCH (mean corpuscular hemoglobin),
 388–391
- MCHC (mean corpuscular hemoglobin
 concentration), 388–391
- MCV (mean corpuscular volume),
 388–391
- Mean corpuscular hemoglobin (MCH),
 388–391
- Mean corpuscular hemoglobin concen-
 tration (MCHC), 388–391
- Mean corpuscular volume (MCV),
 388–391
- Mean platelet volume (MPV), 379
- Measles virus
 rubeola antibody and, 1053
 syphilis serology testing for,
 1081–1083
 viral culture for, 517–519
- Meckel's diverticulum scan, 864–867
- Mediastinal tumor, 302–303
- Mediastinoscopy, 868–871
- Mediastinum, 868–871
- Medications. *See* Drug(s)
- Medullary carcinoma, 1143–1147
- Medullary thyroid cancer, 257–259
- Megakaryocytic hypoproliferation, 380
- Megakaryocytic myelosis, 174–177
- Megaloblastic anemia, 1031–1032
 folate level in, 627–628
 hemoglobin electrophoresis for,
 689–691
 hemosiderin levels in, 692–693
 intrinsic factor antibody and, 759–760
 lactate dehydrogenase levels in,
 775–776
 platelet count in, 380–382
 RBC morphology in, 394
 vitamin B₁₂ and, 1218–1219
 WBC and differential in, 399–403
- Melanin pigment, 461
- Melanoma
 FDG-PET scan for, 599–601
 skin biopsy for, 212–214
- Membrane rupture, premature
 amniotic fluid analysis in, 46
 fetal fibronectin in, 611
 L/S ratio in, 791
 ultrasound biophysical profile in,
 1136
- Membranous glomerulonephritis,
 357–358
 complement protein levels in,
 359–360
- MEN 2A syndrome, 261–263
- MEN type II, 257–259
- Meningioma
 MRI for, 837–839, 859–861
 pituitary CT of, 437–441
- Meningitis
 bacterial culture for, 500–501
 cerebrospinal fluid analysis for,
 295–298
 complement protein levels in,
 357–358
 EEG determining, 563–564
 viral culture for, 518–519
- Meningocele, spine CT in, 446

- Meniscal disease, arthroscopy in, 147–149
- Meniscal tear/laceration
arthrogram of, 144–146
MRI for, 848–850
- Menkes disease
ceruloplasmin levels in, 299–300
copper levels in, 462–463
- Menopause
follicle-stimulating hormone level in, 629–631
luteinizing hormone secretion and, 815–816
osteoporosis and, 344
prolactin level during, 990
- Menorrhagia
aPTT in, 926–929
prothrombin time and, 1008–1011
- Menstruation. *See also* Amenorrhea
ACTH levels in, 10
cancer antigen levels in, 284–285
erythrocyte sedimentation rate and, 577–578
follicle-stimulating hormone levels during, 630
hysterosalpingography and, 728
- Mental retardation, 48–51
- Mercury poisoning, 880–883
- Mesenteric lymphadenopathy, 426–429
- Metabolic acidosis
anion gap for, 83–86
blood gas analysis in, 225, 227
carbon dioxide levels in, 277–279
chloride values in, 308–310
- Metabolic alkalosis
blood gas analysis in, 225, 227
carbon dioxide and, 277
chloride values in, 308–310
- Metabolic complication, transfusion related, 1271
- Metabolic disorder
vitamin C and, 1227
WBC and differential in, 400–403
- Metabolic disturbance, 1028–1029
- Metabolic syndrome
CRP assay for, 471–472
glucose levels in, 659–662
HDL and LDL levels in, 326–329
total cholesterol level in, 331–333
triglyceride levels and, 1109–1111
- Metabolism, 768
- Metachronous lesion, 426–429
- Metal, x-ray-absorbing, 1027–1029. *See also* Metallic objects
- Metal toxicity
ESR and, 577–580
lead and, 790
porphyrin levels in, 960–962
protein levels in, 1004–1006
- Metallic objects
abdominal laparoscopy and, 783
FDG-PET scan imaging and, 599
gastric emptying scan and, 643
gastroesophageal reflux scan and, 649
gastrointestinal blood loss scan, 652
gynecologic laparoscopy and, 786
hepatobiliary scan and, 702
hysterosalpingography and, 728
intravenous pyelography and, 756
KUB study and, 771
liver and spleen scan, 802
lung perfusion scan and, 805
lung ventilation scan and, 808
lymphangiography and, 819
mammography and, 863
MRA and, 829
MRI and, 833, 837, 840–841, 844, 848, 852, 855, 859
myocardial infarction scan and, 886
myocardial perfusion heart scan and, 890–891
parathyroid scan and, 923
PET scan and, 964, 967, 971
radioactive iodine uptake and, 1022
radiofrequency ablation and, 1025
radiography and, 1028
renogram and, 1040
retrograde ureteropyelography and, 1046
retrograde urethrography and, 1184
stereotactic biopsy and, 1075
thyroid scan and, 1091
ultrasonography and, 1130, 1137, 1140, 1143, 1146, 1148, 1151, 1153, 1156, 1159, 1162, 1164, 1167
upper GI series and, 1173
uterine fibroid embolization and, 1200
venogram and, 1208
vertebroplasty and, 1212
white blood cell scan and, 1231
- Metanephrine, 871
- Metastasis
abdominal CT of, 404–407
bone marrow biopsy for, 174–177
chest x-ray and, 301–303
colonoscopy for, 426–429
FDG-PET scan for, 599–601
kidney CT for, 442–445
liver and spleen scan for, 801–803
lymph node biopsy for, 202–205
lymphangiography for, 819–821
MRI for, 837–839, 852–854, 859–861
myocardial infarction scan and, 886
Pap smear and, 917
pelvic CT of, 433–437

- Metastasis (*continued*)
- PET scan for, 971–973
 - phosphorus levels in, 939–942
 - pituitary CT of, 437–441
 - radioactive iodine uptake and, 1022–1023
 - splenic CT of, 450–453
 - thyroid scan for, 1090–1092
 - ultrasonography for, 1148–1149, 1155–1158
- Metastatic bone cancer
- osteocalcin levels in, 904–905
 - scan for, 4, 245–248
- Metastatic carcinoma
- platelet count in, 380–382
 - RBC morphology in, 393–396
- Methanol intoxication, 544–547
- Methemoglobin, 874–876
- Methemoglobinemia, 874–876
- Methicillin resistant *Staphylococcus aureus*, 494–497
- Methionine, 40–41, 709
- Methotrexate, 739–742
- Methylglucamine, 872
- 1-Methylhistine, 40–41
- 3-Methylhistine, 40–41
- Methylmalonic acid, 709–711
- Methylmalonic aciduria, 767–770
- Metyrapone stimulation test, 7–12, 464–467
- MG. *See* Myasthenia gravis (MG)
- Microadenoma, 858–861
- Microalbumin, 876–879. *See also* Albumin (Alb)
- Microalbuminuria, 876
- Microaneurysm, 623–625
- Microangiopathic hemolytic anemia, 692–693
- Microcyte, 363, 392
- Microcytic anemia, 461
- beta₂-Microglobulin, 878–883
- Microhemagglutination, *T. pallidum*, 1081
- Microolithiasis, 1162–1163
- Microorganism, isolation precautions for, 1277–1284
- Microsporium*, 515–516
- Micturition, 520–523
- Micturition disorder, 1159–1160
- Midexpiratory flow, 1013
- Midgut carcinoid tumor, 724–726
- Mifepristone, 543
- Migraine headache
- anticonvulsants for, 119–121
 - EEG determining, 563–564
 - PET scan for, 963–966
- Milk-alkali syndrome
- calcium values in, 261–263
 - phosphorus levels in, 940–942
- Mineralocorticoid deficiency, 1066–1067
- Mining, lead exposure and, 789–791
- Miscarriage, 114
- Mitochondrial CK, 473–474
- Mitral valve abnormality
- echocardiography for, 551–554
 - Holter monitor and, 707–709
 - transesophageal echocardiography of, 555–557
- Mitral valve endocarditis, 114
- Mixed connective tissue disease
- antinuclear antibody and, 106–108
 - anti-ribonucleoprotein and, 106–108
- Mobiluncus cortisii*, 1195
- Mobiluncus mulieris*, 1195
- Modification of Diet in Renal Disease (MDRD), 481
- Monoclonal cell, 736
- Monoclonal gammopathy
- albumin/globulin ratio in, 16–18
 - immunofixation electrophoresis for, 731
 - protein levels in, 996–998, 1004–1006
- Monocytes, 398
- Mononucleosis. *See* Infectious mononucleosis
- Motility disorder, 1172–1174
- MPV (mean platelet volume), 379
- MRA. *See* Magnetic resonance angiography (MRA)
- MRI. *See* Magnetic resonance imaging (MRI)
- Mucopolysaccharidosis, 312–314
- Mucosal damage, 606
- Mucus plug, 30–32
- Multiple dystrophy, 566–567
- Multiple gestation, 792–795
- Multiple myeloma
- amino acid levels in, urine test for, 40
 - beta₂-microglobulin levels in, 880–883
 - bone biopsy for, 170–172
 - cold agglutinin titer levels in, 342–343
 - cryoglobulin detection in, 485–486
 - erythrocyte sedimentation rate and, 577–578
 - fibrinogen level in, 620–622
 - immunofixation electrophoresis for, 731
 - immunoglobulin E level in, 736–738
 - intravenous pyelography and, 756
 - LAP levels in, 795–797
 - protein levels in, 1004–1006
 - RBC count in, 384–388
 - retrograde ureteropyelography and, 1046

- syphilis serology testing for, 1082–1083
 - uric acid level in, 1186–1188, 1189–1191
- Multiple sclerosis
 - brain CT of, 417–420
 - cerebrospinal fluid analysis for, 295–298
 - evoked brain potentials in, 591–594
 - fecal fat and, 606–608
 - MRI for, 837–839
- Multipuncture test, 1118
- Mumps
 - amylase levels in, 52–53
 - pancreatitis and, 658
 - semen analysis and, 1058–1059
 - syphilis serology testing for, 1081–1083
- Mumps serology, 883–885
- Muscle
 - electromyography of, 565–567
 - electroneurography of, 570–572
- Muscle biopsy, 205–208
- Muscle injury
 - alanine aminotransferase levels in, 13–15
 - arthrogram of, 144–146
- Muscle mass
 - blood creatinine clearance test and, 478–479
 - creatinine kinase and, 474–475
 - urine creatinine clearance test and, 482–484
- Muscle necrosis, 975–978
- Muscle relaxants
 - electromyography and, 566
 - sphincter muscle electromyography and, 568–570
- Muscle wasting disease
 - aldolase levels in, 18–19
 - BUN level in, 1178–1180
 - urine creatinine clearance test and, 482–484
- Muscular dystrophy
 - alanine aminotransferase levels in, 13–15
 - aldolase levels in, 18–19
 - amino acid levels in, urine test for, 40
 - aspartate aminotransferase levels in, 150–152
 - blood creatinine clearance test and, 478–479
 - electromyography for, 565–567
 - electroneurography for, 571–572
 - muscle biopsy for, 205–208
 - myoglobin levels in, 894–895
 - pseudocholinesterase level in, 1012
 - pyruvate kinase levels in, 1020
 - skeletal muscle CK-MM and, 474–475
- Musculoskeletal disease, 775–776
- Musculoskeletal system
 - laboratory and diagnostic tests for, 1246
 - MRI of, 847–850
- Myasthenia gravis (MG), 1
 - electromyography for, 566–567
 - electroneurography for, 571–572
 - muscle biopsy for, 205–208
 - myoglobin levels in, 894–895
 - pulmonary function study for, 1016–1017
- Mycobacteria culture/smear, 487–492
- Mycobacterial infection, 500–501
- Mycobacterium avium intracellulare*, 487–488
- Mycobacterium* culture and smear, 487
- Mycobacterium fortuitum*, 488
- Mycobacterium kansasii*, 488
- Mycobacterium leprae*, 488
- Mycobacterium marinum*, 488
- Mycobacterium tuberculosis*, 487–488. *See also* Tuberculosis
- Mycobacterium xenopi*, 488
- Mycoplasma pneumoniae*, 457
 - cold agglutinin titer levels and, 341–343
 - syphilis serology testing for, 1081–1083
- Mydriatics
 - fundus photography and, 634
 - refraction and, 1033
 - slit-lamp biomicroscopy and, 1063
- Myelocoele, 446–449
- Myelocytic leukemia, 400–403
- Myelofibrosis
 - bone marrow biopsy for, 174–177
 - folate level in, 627–628
 - LAP levels in, 795–797
 - platelet count in, 380–382
 - RBC morphology in, 393–396
- Myelogenous leukemia, 796–797
- Myeloid leukemia
 - bone marrow biopsy for, 174–177
 - platelet antibody and, 948–949
- Myeloid metaplasia, 795–797
- Myeloma
 - apolipoprotein B and, 141–143
 - calcium values in, 260–263
 - FDG-PET scan for, 599–601
 - hexosaminidase level in, 705–706
 - immunoglobulin E level in, 734–735
 - LDL level in, 327–329
 - protein level in, 996–998
 - radiography for, 1028–1029
 - RBC morphology in, 393–396
 - total cholesterol level in, 331–333
 - urinary calcium levels in, 268–271
 - WBC and differential in, 400–403

- Myelomeningocele, 1136–1139
- Myeloproliferative disorder
bleeding time in, 220
eosinophil count in, 573–575
hemoglobin electrophoresis and, 689–691
- Myocardial infarction, 254–255
alanine aminotransferase levels in, 13–15
aldolase levels in, 18–19
alkaline phosphatase levels in, 25–26
blood pool imaging for, 239–241
cardiac CK-MB and, 474–475
catecholamine levels in, 287–290
complement protein levels in, 357–358
copper levels in, 462–463
creatine kinase and, 473–474
CRP assay for, 470–472
electrocardiogram for, 558–561
exercise stress test for, 594–597
fibrin degradation product and, 618–619
fibrinogen level in, 620–622
glucose levels in, 658–662
G6PD levels and, 663
haptoglobin level in, 686–687
hexosaminidase level in, 705–706
lactate dehydrogenase levels in, 775–776
MRI for, 843–846, 844–846
myocardial perfusion heart scan for, 888–893
myoglobin levels in, 894–895
pericardial fluid analysis for, 932–934
PET scan for, 967–970
proctosigmoidoscopy and, 986
pseudocholinesterase level in, 1012
pyruvate kinase levels in, 1020
transesophageal echocardiography of, 555–557
triglyceride levels and, 1109–1111
troponin level in, 1117–1118
WBC and differential in, 400–403
zinc level in, 1235–1236
- Myocardial infarction imaging, 885
- Myocardial infarction scan, 885–888
- Myocardial perfusion heart scan, 888–893
- Myocarditis, 254–255
cardiac CK-MB and, 474–475
myocardial infarction scan and, 886
- Myocardium, 558, 886
- Myoclonic seizure, 563–564
- Myoglobin (MB), 764–765, 893–895
- Myoma, 1199–1202
- Myopathy
carbon dioxide levels in, 277–279
neuropathy versus, 566–567
primary, 565–567
- Myopia, 1032–1035
- Myositis
alanine aminotransferase levels in, 13–15
aldolase levels in, 18–19
WBC and differential in, 400–403
- Myotonia congenita, 205–208
- Myotonic dystrophy, 1085–1086
- Myxedema, 640–642
- Myxoma
echocardiography for, 551–554
transesophageal echocardiography of, 554–557
- N**
- N*-Acetyl procainamide, 86–92
- Nails, fungal culture of, 515–516
- Narcolepsy, 563–564
- Narcotic addiction. *See* Drug abuse
- Narrow-angle glaucoma
fluorescein angiography and, 624
fundus photography and, 634
refraction and, 1033
slit-lamp biomicroscopy and, 1062–1063
- Nasogastric feeding, 1065–1067
- Nasogastric feeding tube, chest x-ray and, 301–303
- Nasogastric suction
chloride loss from, 308–310
potassium levels and, 976–978
- Nasopharyngeal area, 509–511
- Nasopharyngeal carcinoma, infectious mononucleosis and, 742–744
- National Cholesterol Education Program (NCEP), 1108
- Natural product, laboratory values and, 1274–1276
- Nausea. *See also* Vomiting
acetaminophen intoxication and, 55
antiarrhythmic toxicity and, 89
anticonvulsant toxicity and, 120
GER scan and, 648
magnesium and, 823
salicylate intoxication and, 55
- Near drowning
blood gas analysis in, 226–232
potassium levels and, 975–978
- Nearsightedness, 1032–1035
- Necator americanus* infection, 908–909
- Neck, 1166–1168
evaluation of pain in, 1021
MRI of, 836
- Neck cancer. *See* Head and neck cancer
- Necrosis
avascular, 848–850
bone scan for, 246
coumarin-induced, protein S and, 1001–1003

- CT of, 417
 fibrinogen and, 620
 liver, 40
 MRI of, 847, 848
 muscle, 975–978
 PET and, 963, 967
 potassium and, 975
 prealbumin and, 983
 radiation, 963–966
 tissue. *See* Tissue necrosis
 tubular
 MRI for, 833–835
 renogram for, 1040–1042
- Necrotizing-crescentic glomerulonephritis, 103–104
- Needle biopsy. *See also* Fine-needle aspiration biopsy
 bone, 171
 bone marrow, 176
 breast, 180
 kidney, 192, 193
 liver, 195, 196
 lung, 200
 lymph node, 203, 204
 muscle, 207
 thyroid, 216, 217
 vacuum-assisted, 1074
- Needlestick Safety and Prevention Act, 1290
- Neisseria*, 509
Neisseria catarrhalis, 501
Neisseria gonorrhoeae
 culture for, 494, 509
 DNA probe assays for, 492
- Nelson's syndrome, 10
- Neonatal hyaline membrane disease, 946–947
- Neonatal immune thrombocytopenia, 948–949
- Neonatal lupus, 106–108
- Neonatal prematurity, 261–263
 copper levels in, 462–463
 ionized calcium values in, 265–267
- Neonatal seizure, 1228
- Neonate. *See* Neonatal *entries* and Newborn
- Neoplasms. *See* Tumor(s), *particular tumor types*, and *site-specific entries*
- Neoplastic disease. *See specific conditions*
- Neovascularization
 fluorescein angiography for, 623–625
 gonioscopy for, 676–677
- Nephritis, 106–108, 742–744. *See also*
 Glomerulonephritis
 chloride values in, 308–310
 erythrocyte sedimentation rate and, 577–578
 iron level in, 762–764
 renin value in, 1036–1039
- Nephroblastoma, 581–582
- Nephrogenic diabetes insipidus
 antidiuretic hormone and, 129–130
 sweat chloride values in, 312–314
- Nephrolithiasis. *See* Renal calculi
- Nephropathy. *See also* Kidney disease
 microalbumin and, 877–879
 protein levels in, 1004–1006
 renin value in, 1036–1039
- Nephrosis
 iron level in, 762–764
 urinary calcium levels in, 269–271
- Nephrotic syndrome, 129–130
 aldosterone levels in, 20–22
 alpha₁-antitrypsin levels in, 138–139
 amino acid levels in, blood test for, 37–38
 antithrombin III levels in, 135–136
 apolipoprotein A and, 141–143
 apolipoprotein B and, 141–143
 copper levels in, 462–463
 fibrinogen level in, 620–622
 HDL and LDL levels in, 326–329
 hyperlipoproteinemia and, 799–800
 immunoglobulin E level in, 737–738
 kidney biopsy for, 191–194
 protein level in, 996–998, 1004–1006
 pseudocholinesterase level in, 1011–1012
 sodium levels and, 1066–1067
 TBG level in, 1098–1099
 total cholesterol level in, 330–333
 total thyroxine level and, 1102–1104
 triglyceride levels and, 1109–1111
 zinc level in, 1235–1236
- Nephrotoxic agent, 1178–1180
- Nerve fiber analysis, 896–898
- Nerve transection, 570
- Neural tube defect
 AFP levels in, 613–617
 amniotic fluid analysis for, 47–51
- Neuralgia, trigeminal, 119
- Neuritis
 optic, 1215–1217
 retrobulbar, 591–594
- Neuroblastoma
 catecholamine levels in, 287–290
 homovanillic acid level in, 712–714
 metanephrine levels and, 872–873
 vanillylmandelic acid level in, 1203–1205
- Neurofibroma, skin biopsy for, 212–214
- Neurogenic bladder
 cystometry and, 520–523
 voiding cystourethrography for, 527–529
- Neurogenic pain, 119

- Neuromuscular dysfunction
 human T-lymphotropic virus antibodies and, 722–724
 sphincter muscle electromyography and, 568–570
 vitamin E and, 1222–1224
- Neuromuscular junction, 565–567
- Neuromuscular junction testing, 565–570
- Neuropathy
 diabetic
 anticonvulsants for, 119–121
 electromyography in, 566–567
 electroneurography for, 570
 myopathy versus, 566–567
 optic, 1215–1217
 peripheral, 566–567
 sensorimotor, 591–594
- Neutropenia, 461–463
- Neutrophil cell, 398
- Nevus
 choroidal
 fundus photography and, 634–635
 visual field test and, 1215–1217
 pigmented, biopsy for, 212–214
- Newborn. *See also* Neonatal *entries*
 amino acid screen in, 39–41
 beta₂-microglobulin levels in, 879
 filter paper test and, 1095
 glucose levels in, 657
 G6PD levels in, 662
 haptoglobin level in, 685
 hemolytic disease of, 902–903
 nonimmunological hemolytic disease of, 663
 obstructive jaundice in, 670–672
 osmotic concentration in, 899–902
 protein level in, 996
 reticulocyte count in, 1042
 sodium levels in, 1065
 TBG level in, 1098–1099
 vitamin B₁₂ level in, 1217
- Niacin, 1226
- Nicotine. *See also* Smoking
 effect on EEG, 563
- Nicotine dependence, 126–128
- Niemann-Pick disease, 4
- Night blindness, 1227, 1228
- Nipple drainage, 1074
- Nitrazine test, 46
- Nitrendipine, 543
- Nitrite, 1195, 1197
- NMP (nuclear matrix protein), 218
- Nocardia*, 250–253
- Nodal lymphoma, 819–821
- Nodular hyperplasia, 801–803
- Nonimmunological hemolysis, transfusion related, 1271
- Nonimmunological hemolytic disease of newborn, 663
- Non-insulin-dependent diabetes (type 2).
See also Diabetes mellitus
 C-peptide levels in, 468
 insulin levels in, 745
- Nonparathyroid hypercalcemia, 921–922
- Nonspherocytic anemia
 G6PD levels in, 663
 pyruvate kinase levels in, 1020
- Nonstress test (NST), 1134
- Nonthyroidal disease, 1114–1116
- Nontoxic nodular goiter, 215–217
- Nontropical sprue. *See* Celiac disease
- Nocardia*, 514–516
- Norepinephrine, 286–290
 homovanillic acid and, 712
 vanillylmandelic acid and, 1203
- Normal flora, 501, 506
- Normetanephrine, 871
- Normochromic cell, 394
- Nortriptyline, 124–128
- Norwalk virus, 517–519
- Nosebleed, vitamin K and, 1225
- NST (nonstress test), 1134, 1135
- N-terminal parathyroid hormone, 919–922
- NT_x (collagen cross-linked N-telopeptide), 344–346
- Nuclear matrix protein (NMP), 218
- Nuclear medicine scan, 807–810
- Nuclear scan
 gallium scan and, 637
 gastric emptying scan and, 643
 gastrointestinal blood loss scan, 652
 hepatobiliary scan and, 702
 liver and spleen scan, 802
 lung perfusion scan and, 805
 lung ventilation scan and, 808
 myocardial infarction scan and, 886
 parathyroid scan and, 923
 thyroid scan and, 1090
 white blood cell scan and, 1232
- Nucleic acid amplification test (NAT), 698–700
- Nucleic acid synthesis, 825
- Nutritional consideration, 1247
- Nutritional deficiency. *See* Malnutrition
- Nystagmus, 1215–1217
- O**
- Oat cell carcinoma, 724–726
- Obesity
 cardiac scoring for, 421–424
 HDLC level in, 326–329
 insulin levels in, 745–747
 myocardial perfusion heart scan and, 890

- pseudocholinesterase level in, 1011–1012
- pulmonary function study for, 1016–1017
- total cholesterol level in, 330–333
- total thyroxine level and, 1102–1104
- triglyceride levels and, 1109–1111
- ultrasonography and, 1137
- vitamin B₁₂ and, 1218–1219
- Obligate cell parasite, 304–306
- Obsessive-compulsive disorder (OCD), 126–128
- Obstruction. *See also specific types of obstruction*
- echocardiography for, 551–554
- upper GI series for, 1172–1174
- Obstructive jaundice
- GGT levels in, 670–672
- lactate dehydrogenase levels in, 775–776
- vitamin K and, 1225–1226
- Obstructive liver disease
- GGT levels in, 670–672
- vitamin E and, 1223–1224
- Obstructive uropathy, 1040–1042
- Occipital horn syndrome (OHS), 462–463
- Occlusion
- CT angiography of, 408–412
- ultrasonography for, 1129–1131
- visual field test for, 1215–1217
- Occlusion effect, 1122
- Occult blood, 602
- Occupational Safety and Health Administration (OSHA)
- bloodborne pathogen standards, revisions to, 1289–1292
- final rule, 1280–1283
- standard precautions, 1285–1287
- transmission-based precautions, 1277–1279
- Ocular hemorrhage, 676–677
- Ocular hypertension, 896–898
- Ocular motility, 750–752
- Ocular neoplasm in angle, 676–677
- Ocular system, 1247
- OHS (occipital horn syndrome), 462–463
- Oligospermia, 1057–1059
- Open biopsy. *See also Biopsy*
- bladder, 168
- bone, 171
- breast, 180
- kidney, 192, 193
- liver, 195, 196
- lung, 199
- lymph node, 203, 204
- muscle, 207
- thyroid, 216
- Open-angle glaucoma, 752–755
- Ophthalmia neonatorum, 304–306
- Opiate abuse, 544–547
- Optic nerve lesion, 591–594
- Optic nerve tumor, 837–839
- Optic neuritis, 1215–1217
- Optic neuropathy, 1215–1217
- Oral anticoagulant, 127–128
- Oral anticoagulant therapy, 999–1001, 1002–1003
- Oral contraceptive, 543
- Oral flora, 501, 510
- Orchiectomy, 1085–1086
- Orchitis
- follicle-stimulating hormone level in, 629–631
- infertility and, 109–110
- mumps and, 883
- semen analysis for, 1058–1059
- ultrasonography for, 1162–1163
- Organ
- rejection of, 740–742
- x-ray of, 1027–1029
- Organ failure, 265–267
- Organ infarction, 58–61
- Organ transplant, 537
- Organomegaly, 771–772
- Organophosphate pesticide, 1030
- Ornithine, 40–41
- Orthostatic hypotension, 288–290
- OSHA. *See Occupational Safety and Health Administration (OSHA)*
- Osmolality, 899–902
- Osmotic fragility, 902–903
- Osteitis deformans. *See Paget's disease*
- Osteoarthritis
- arthroscopy of, 147–149
- synovial fluid analysis and, 1078–1080
- Osteoblast
- osteocalcin levels and, 903
- vitamin D and, 1220
- Osteoblastic metastasis, 269–271
- Osteocalcin, 903–905
- Osteochondral fracture, 144–146
- Osteochondritis, 147–149
- Osteochondritis dissecans, 144–146
- Osteochondroma, 848–850
- Osteogenic sarcoma. *See Osteosarcoma*
- Osteolytic bone metastasis, 268–271
- Osteoma, 170–172
- Osteomalacia, 261–263
- amino acid levels in, urine test for, 40
- NTx for, 345–346
- phosphorus levels in, 940–942
- urinary calcium levels in, 269–271
- vitamin D and, 1220–1222

- Osteomyelitis
 bacterial culture for, 500–501
 bone scan for, 245–248
 MRI for, 848–850
 radiography for, 1028–1029
 white blood cell scan for, 1231–1233
- Osteopenia, 1028–1029
- Osteoporosis
 alkaline phosphatase levels in, 24–26
 bone mineral densitometry for, 242–245
 copper levels in, 461–463
 NT_x for, 344–346
 osteocalcin levels and, 904–905
 radiography for, 1028–1029
 urinary calcium levels in, 268–271
 vertebroplasty for, 1211–1214
- Osteosarcoma
 alkaline phosphatase levels in, 24–26
 bone biopsy for, 170–172
 MRI for, 848–850
 radiography for, 1028–1029
 zinc level in, 1234–1236
- Otitis externa
 hearing loss audiometry for, 154–156
 otoscopy for, 906–907
- Otitis media
 hearing loss audiometry for, 154–156
 otoscopy for, 906–907
- Otosclerosis, 154–156
- Otoscopy, 905–907
- Ototoxic drugs, 154–156
- Ova and parasites, 603–604
- Ovalocyte, 364, 392
- Ovarian abscess, 284–285
- Ovarian cancer
 cancer antigen levels in, 284–285
 FDG-PET scan for, 599–601
- Ovarian carcinoid tumor, 725–726
- Ovarian carcinoma, 614–617
- Ovarian cyst
 gynecologic laparoscopy for, 786–788
 pelvic CT of, 433–437
 ultrasonography for, 1156–1158
- Ovarian failure, 589–590
- Ovarian hyperfunction, 1009–1011
- Ovarian hypofunction, 1098–1099
- Ovarian inflammation, 883
- Ovarian tumor
 amylase levels in, 52–53
 gynecologic laparoscopy for, 786–788
 progesterone testing for, 989–990
 testosterone and, 1085–1086
- Ovary, 785–788
- Overhydration
 albumin/globulin ratio, 16–18
 chloride values in, 308–310
 RBC count in, 385–388
- Ovulation, 988–990
- Oxalate, 910–912
- Oxalate kidney stone disease, 911
- Oxidation, 1222–1224
- Oxidative phosphorylation, 825
- Oxygen partial pressure, in blood, 222, 224
 in acidosis, 225
 in alkalosis, 225
- Oxygenation, 29–32
- Oxytocin challenge test, 1135
- P**
- P53, in breast cancer, 177, 178
- P wave enlargement, 559–561
- Pacemaker
 chest x-ray and, 301–303
 MRA and, 829
 MRI and, 833, 837, 841, 844, 848, 852, 855, 859
- Pachymetry, 913–914
- Packed cell volume. *See* Hematocrit
- Paget's disease
 AcP levels in, 4
 alkaline phosphatase levels in, 24–26
 bone scan for, 245–248
 calcium values in, 261–263
 NT_x for, 345–346
 osteocalcin levels and, 904–905
 radiography for, 1028–1029
 urinary calcium levels in, 268–271
- Pain
 abdominal. *See* Abdominal pain
 acetaminophen/acetysalicylic acid for, 54
 antidiuretic hormone and, 129–130
 back, 1212–1214
 MRI in, 848
 breast, mammogram in, 861
 carbamazepine for, 119
 chest. *See* Chest pain
 ear, 905–907
 epigastric
 esophagogastroduodenoscopy for, 586–589
 pancreatic CT in, 430
 upper GI series for, 1172–1174
 flank, bladder ultrasonography and, 1139
 joint
 arthroscopy in, 146
 bone scan in, 246
 Lyme disease and, 816
 lower extremity, 1208
 neck, RAIU in evaluation of, 1021
 neurogenic, 119
 pelvic
 fibroids and, 1199
 laparoscopy in, 786

- perineal, proctosigmoidoscopy in, 985
- RFA and, 1024
- right upper quadrant, 1147–1149
- scrotal, 1161
- suprapubic, 1139
- vertebroplasty for, 1211, 1212
- Paint, lead in, 789–791
- Pallister-Killian syndrome, 334
- Palpitation, 707–709
- PAMG-1 (placental alpha-microglobulin-1) protein, 47
- p-ANCA (perinuclear antineutrophil cytoplasmic antibody), 102–104
- Pancreas
- computed tomography of, 429–433
 - MRA of, 851
 - MRI of, 851–854
 - ultrasonography of, 1152–1154
- Pancreatotomy
- amylase levels in, 52–53
 - C-peptide levels in, 468–469
- Pancreatic adenoma, 658–662
- Pancreatic calculi, 852–854
- Pancreatic cancer, 24–26
- Pancreatic carcinoma
- amylase levels in, 52–53
 - calcitonin stimulation test for, 257–259
 - cancer antigen levels in, 284–285
 - ERCP in, 321–324
 - FDG-PET scan for, 599–601
 - human chorionic gonadotropin level in, 716–717
 - lipase levels in, 797–799
 - total cholesterol level in, 330–333
 - vitamin E and, 1223–1224
- Pancreatic cyst
- amylase levels in, 52–53
 - lipase levels in, 797–799
- Pancreatic deficiency, 603–604
- Pancreatic disease
- oxalate levels in, 910–912
 - vitamin K and, 1225–1226
- Pancreatic duct, obstruction of
- lipase levels in, 797–799
 - MRI for, 852–854
 - pancreatic CT of, 429–433
 - ultrasonography for, 1153–1154
- Pancreatic fatty infiltration, 852–854
- Pancreatic fibrosis, 321–324
- Pancreatic inflammation. *See* Pancreatitis
- Pancreatic insufficiency, 261–263
- amylase levels in, 52–53
 - fecal fat and, 606–608
 - vitamin D and, 1220–1222
- Pancreatic islet cell tumor, 666–669
- Pancreatic mass, 852–854
- Pancreatic obstruction, 606–608
- Pancreatic pseudocyst
- abdominal CT of, 404–407
 - lipase levels in, 797–799
- Pancreatic transplant, 468–469
- Pancreatic tumor, 1153–1154
- Pancreatitis
- alanine aminotransferase levels in, 13–15
 - aldolase levels in, 18–19
 - amino acid levels in, blood test for, 37–38
 - amylase levels in, 52–53
 - aspartate aminotransferase levels in, 150–152
 - calcitonin stimulation test for, 257–259
 - calcium values in, 261–263
 - cancer antigen levels in, 284–285
 - CT in, 429–433
 - ERCP in, 321–324
 - GGT levels in, 670–672
 - glucagon level in, 655–657
 - glucose levels in, 658–662
 - ionized calcium values in, 265–267
 - lactate dehydrogenase levels in, 775–776
 - lipase levels in, 797–799
 - magnesium level and, 823–824
 - MRI for, 852–854
 - mumps and, 883
 - percutaneous transhepatic cholangiography in, 315–318
 - platelet count in, 379–382
 - pleural fluid analysis and, 956–958
 - sweat chloride values in, 311–314
 - triglyceride levels and, 1109–1111
 - ultrasonography for, 1153–1154
 - vitamin E and, 1223–1224
- Panhypopituitarism, 1102–1104
- Panic attack, 595–597
- Panic disorder, 126–128
- Papanicolaou (Pap) test, 353, 915–919
- Papillary carcinoma, 1143–1147
- Papilloma
- colposcopy for, 353–355
 - ultrasonography for, 1143–1147
- Pappenheimer body, 364, 392, 1044
- Pappenheimer body stain, 691
- Paracentesis, 16–18
- Paracoccidioides brasiliensis*, 515–516
- Parainfluenza virus, 517–519
- Paralysis
- albumin/globulin ratio, 16–18
 - potassium levels and, 976–978
 - urine creatinine clearance test and, 482–484
- Parasitic infection. *See also specific organisms*
- albumin/globulin ratio in, 16–18
 - complement protein levels in, 357–358

Parasitic infection (*continued*)

- D-xylose tolerance test for, 547–550
- eosinophil count in, 573–575
- fecal analysis for, 603–604
- immunoglobulin E level in, 734–735
- intestinal biopsy for, 188–190
- liver biopsy for, 194–197
- lymph node biopsy for, 202–205
- MRI for, 859–861
- muscle biopsy for, 205–208
- sputum cytology for, 530–534
- WBC and differential in, 399–403
- Paraspinal cyst, 446–449
- Parathyroid adenoma, 923–925
- Parathyroid gland, 1166–1168
 - autoimmune destruction of, 921–922
- Parathyroid hormone, 919–922. *See also*
 - Hyperparathyroidism;
 - Hypoparathyroidism
- Parathyroid hormone-producing neoplasm, 265–267, 940–942
- Parathyroid hyperplasia, 1167–1168
- Parathyroid scan, 923–925
- Parathyroid tumor, 1167–1168
- Parenteral nutrition, total
 - ammonia levels with, 44–45
 - copper levels in, 462–463
 - hepatobiliary scan and, 702
 - vitamin E and, 1222–1224
 - zinc level in, 1235–1236
- Parkinson's disease
 - catecholamine levels in, 288–290
 - evoked brain potentials in, 591–594
 - FDG-PET scan for, 598–601
 - MRI for, 837–839
 - PET scan for, 963–966
- Parotitis. *See also* Mumps
 - amylase levels in, 52–53
 - viral culture for, 518–519
- Paroxysmal atrial tachycardia, 153
- Paroxysmal cold hemoglobinuria, 457–458
- Paroxysmal hemoglobinuria, 948–949
- Paroxysmal hypertension, 640–642
- Paroxysmal nocturnal hemoglobinuria, 692–693
 - cholinesterase enzyme in, 1031–1032
 - Ham's test for, 683
 - LAP levels in, 796–797
 - platelet count in, 380–382
- Partial acid fast, 678
- Partial thromboplastin time, activated, 925–929
- Parvovirus, 517–519
- Parvovirus B19, 929–931
- Patau syndrome, 334
- Paternity verification, semen analysis for, 1057–1059

Patient

- isolation precautions, 1279–1280
- preparation for testing, 1251
- Paul-Bunnell-Davidsohn antibody, 742–744
- Pb. *See* Lead
- PCNA (proliferating cell nuclear antigen), in breast cancer, 177, 178
- PCP intoxication, 545
- PDW (platelet distribution width), 379
- Peak acid output (PAO), 639–642
- Peak expiratory flow rate, 1014
- Peak inspiratory flow rate, 1014
- Peau d'orange skin, 1074
- Pediatric urine collector
 - for bacteria culture, 513
 - for urinalysis, 1198
 - for urine cytology, 535
- Pellagra
 - copper levels in, 462–463
 - vitamin B₃ and, 1228
 - vitamin B₆ and, 1228
- Pelvic abscess, 1156–1158
- Pelvic adhesion, 786–788
- Pelvic floor sphincter electromyography, 568–570
- Pelvic gynecologic sonogram, 1155–1158
- Pelvic inflammatory disease
 - cancer antigen levels in, 284–285
 - Chlamydia* antibody testing for, 304–306
 - gynecologic laparoscopy for, 786–788
 - hysterosalpingography and, 728
 - ultrasonography for, 1155–1158
- Pelvic pain
 - fibroids and, 1199
 - laparoscopy in, 786
- Pelvic tumor
 - gynecologic laparoscopy for, 786–788
 - voiding cystourethrography for, 527–529
- Pelvic vascular disease, 855–857
- Pelvic vein compression, 952
- Pelvis
 - computed tomography of, 433–437
 - FDG-PET scan of, 598–601
 - MRA of, 855
 - MRI of, 854–857
 - PET scan of, 970–973
 - ultrasonography of, 1150–1152, 1155–1158
- Pemphigus, 212–214
- Penetrating keratoplasty, 913–914
- Penicillin, 734
- Pentagastrin stimulation, 256–259
- Peptic ulcer
 - albumin/globulin ratio in, 16–18
 - amylase levels in, 52–53

- fecal fat and, 606–608
gastric acid stimulation test and, 639–642
- Pepto-Bismol, 1175
- Peptostreptococcus* spp., 494–497
- Percutaneous transhepatic cholangiography, 314–318
- Percutaneous umbilical cord sampling, 1256
- Perforated bowel, 274–276
abdominal CT of, 404–407
alkaline phosphatase levels in, 25–26
barium enema for, 157–159
capsule endoscopy for, 274–276
upper GI series for, 1172–1174
- Perforated esophagus. *See* Esophageal perforation/rupture
- Perforated stomach, 1172–1174
- Periaortic hematoma, 844–846
- Pericardial effusion
chest x-ray for, 302–303
echocardiography for, 551–554
MRI for, 844–846
transesophageal echocardiography of, 554–557
- Pericardial fluid analysis, 931–934
- Pericardial hematoma, 844–846
- Pericardial mass, 844–846
- Pericardial tamponade, 551–554
- Pericarditis
aspartate aminotransferase levels in, 150–152
chest x-ray for, 302–303
echocardiography for, 551–554
electrocardiogram for, 559–561
myocardial infarction scan and, 886
- Pericardium, 931
- Perineal pain, proctosigmoidoscopy in, 985
- Perinephric abscess, 1045–1048
- Perinephric inflammation/suppurative, 1045–1048
- Perinuclear antineutrophil cytoplasmic antibody (p-ANCA), 102–104
- Peripheral anterior synechiae (PAS), 676–677
- Peripheral arterial occlusive disease, 595–597
- Peripheral atherosclerotic disease, 950–954
- Peripheral motor neuron disease, 565–567
- Peripheral nerve damage, 571–572
- Peripheral neuropathy, 565–567
- Perirectal abscess, 1159–1160
- Perirectal tumor, 1159–1160
- Perirenal abscess, 1145–1147
- Perirenal hematoma, 1145–1147
- Perisellar abnormality, 858–861
- Peritoneal effusion, 936–938
- Peritoneal fluid analysis, 935–938
- Peritoneal perforation, 935–938
- Peritoneal rupture, 935–938
- Peritoneal tumor, 855–857
- Peritonitis
amylase levels in, 52–53
cancer antigen levels in, 284–285
MRI for, 855–857
ultrasonography for, 1156–1158
- Pernicious anemia
alkaline phosphatase levels in, 25–26
amino acid levels in, urine test for, 40
antithyroglobulin/antithyroid peroxidase antibody in, 112–113
bilirubin levels in, 164–166
bone marrow biopsy in, 174
calcitonin stimulation test for, 257–259
fecal fat and, 606–608
folate level in, 626–628
gastric acid stimulation test and, 640–642
gastrin stimulation test for, 645–647
G6PD levels in, 663
hemosiderin levels in, 692–693
intrinsic factor antibody and, 759–760
iron level in, 762–764
lactate dehydrogenase levels in, 775–776
RBC indices in, 389–391
sickle cell screen and, 1060
total cholesterol level in, 331–333
uric acid level in, 1189–1191
vitamin B₁₂ and, 1218–1219
WBC and differential in, 400–403
- Personal protective equipment, 1280–1281
- Pesticide toxicity, 1030
- PET. *See* Positron emission tomography (PET)
- Petit mal seizure, 563–564
- pH
blood, 223
in acidosis, 225
in alkalosis, 225
urine, 1194
- Phagocytosis, 398
- Pharyngitis, 509–511, 518–519
- Phenazopyridine, 547–550
- Phencyclidine, 544–547
- Phenobarbital, 117–121
- Phenylalanine, 40–41
- Phenylketonuria, 725–726
- Phenytoin, 117–121, 543

- Pheochromocytoma**
 adrenal angiography of, 63–65
 adrenal scintiscan for, 5–7
 calcitonin stimulation test for, 257–259
 calcium values in, 261–263
 catecholamine levels in, 287–290
 erythropoietin level in, 581–582
 glucose levels in, 658–662
 glucose tolerance test for, 666–669
 homovanillic acid level in, 712–714
 metanephrine levels and, 872–873
 renin value in, 1036–1039
 vanillylmandelic acid level in, 1203–1205
- Phlebography**, 1207
- Phosphoethanolamine**, 40–41
- Phosphorus**
 in blood specimen, 939–942
 in urine specimen, 942–945
- Phosphoserine**, 40–41
- Photosensitivity**, 106–108
- Phycomycosis**, 250–253
- Phyllodes tumor**, 1143–1147
- Phylloquinone**. *See* Vitamin K *entries*
- Phytonadione**. *See* Vitamin K *entries*
- Pi phenotype**, 136–139
- Pica**, 976–978
- Picornavirus**, 693
- Pigmented nevus, biopsy for**, 212–214
- Pill GI endoscopy**, 273–276
- Pinhole test**, 1032
- Pinworm infection**, 908–909
- Pitocin challenge test**, 1135
- Pituitary adenoma**, 437–441
- Pituitary area**, 858–861
- Pituitary diabetes insipidus**, 129–130
- Pituitary disorder**, 991–993
- Pituitary dysfunction**, 815–816
- Pituitary gland**
 computed tomography of, 437–441
 thyroid-stimulating hormone and, 1093
- Pituitary hemorrhage**, 438–441
- Pituitary hypothalamic dysfunction**, 1093–1095
- Pituitary microadenoma**, 837–839
- Pituitary tumor**
 CRH stimulation for, 9–10
 MRI for, 858–861
 prolactin level in, 991–993
- Pituitary vascularity**, 858–861
- PK (pyruvate kinase)**, 1020
- Placenta previa**
 lecithin/sphingomyelin ratio in, 792–795
 ultrasonography for, 1136–1139
- Placental alpha-microglobulin-1 (PAMG-1) protein**, 47
- Placental infarction**, 792–795
- Placental infection**, 114
- Plague**, 498–501
- Plaque**
 homocysteine level and, 709
 ultrasonography for, 1129–1131
- Plasma**, 1030
- Plasma protein**, 577–578
- Plasma renin activity (PRA)**, 1035–1039
- Plasmapheresis**, 1012
- Plasminogen**, 945–947
- Platelet aggregation**, 709
- Platelet alloantibody**, 948–949
- Platelet antibody**, 948–949
- Platelet autoantibody**, 948–949
- Platelet count**, 814–816, 925–929
 aPTT and, 927
 complete blood count and, 364–367, 378–382
- Platelet distribution width (PDW)**, 379
- Platelet-bound IgG/IgM, direct and indirect**, 948–949
- Plesiomonas shigelloides*, 507–509
- Plethysmography**, 950–954
- Pleural effusion**, 956–958
 blood gas analysis in, 226–232
 chest x-ray for, 302–303
 MRI for, 843–846
 pleural fluid analysis and, 956–958
 thoracic CT for, 454–456
- Pleural fluid analysis**, 954–958
- Pleurodynia**, 518–519
- Ploidy**, 178
 DNA, in breast cancer, 177, 178
- Plummer's disease**, 1090–1092
- PMM certificate**, 1273
- Pneumococcal pneumonia**
 complement protein levels in, 357–358
 syphilis serology testing for, 1081–1083
- Pneumoconiosis**, 202–205
- Pneumocystis jiroveci (carinii)*
 AIDS and, 530–534
 bronchoscopy for, 250
 gallium scan for, 636
 lung biopsy for, 198–201
 mediastinoscopy for, 868–871
- Pneumonia**, 518–519
 alkaline phosphatase levels in, 25–26
 antidiuretic hormone and, 129–130
 blood gas analysis in, 226–232
 bone marrow biopsy for, 174–177
 carbon dioxide levels in, 277–279
 chest x-ray for, 302–303
 complement protein levels in, 357–358
 erythrocyte sedimentation rate and, 577–578

- lung perfusion scan for, 805–807
- lung ventilation scan for, 808–810
- plethysmography for, 951–954
- pleural fluid analysis and, 956–958
- WBC and differential in, 400–403
- Pneumonitis**
 - lung perfusion scan for, 805–807
 - thoracic CT for, 454–456
- Pneumoperitoneum**, 302–303
- Pneumothorax**, 30–32
 - blood gas analysis in, 226–232
 - chest x-ray for, 302–303
 - thoracic CT for, 454–456
- Poikilocyte**, 363, 392
- Poisoning**, 84–86
 - blood gas analysis in, 226–232
 - copper levels in, 462–463
 - erythrocyte sedimentation rate and, 577–578
 - from iron levels, 761
 - from metals, beta₂-microglobulin and, 880–883
 - oxalate levels in, 910–912
 - WBC and differential in, 400–403
- Poliomyelitis**
 - blood creatinine clearance test and, 477–479
 - blood gas analysis in, 226–232
 - carbon dioxide levels in, 277–279
 - electroneurography for, 571–572
- Polyangiitis**, 103–104
- Polychromasia**, 364, 392
- Polychromic cell**, 394
- Polyclonal gammopathy**, 996–998
- Polycystic kidney disease**
 - AFP levels in, 615–617
 - amino acid levels in, blood test for, 37–38
 - erythropoietin level in, 581–582
 - kidney CT for, 442–445
 - retrograde ureteropyelography for, 1045–1048
 - ultrasonography for, 1145–1147
 - uric acid level in, 1186–1188
 - urine creatinine clearance test and, 482–484
- Polycystic ovary/polycystic ovary disease**, 630–631
 - DHEAS and, 542–543
 - prolactin level in, 991–993
 - testosterone and, 1085–1086
- Polycythemia**
 - EPO and, 581
 - ESR in, 578
 - Hct and, 368, 369
 - Hgb and, 373, 375
 - RBC count and, 383, 385
 - uric acid and, 1186
- Polycythemia vera**, 373–378, 383–388
 - bone marrow biopsy for, 174–177
 - calcium values in, 261–263
 - erythrocyte sedimentation rate and, 577–578
 - erythropoietin level in, 581–582
 - hematocrit in, 369–372
 - hemoglobin in, 374–378
 - LAP levels in, 795–797
 - MRI for, 848–850
 - platelet count in, 379–382
 - sickle cell screen and, 1061
 - total cholesterol level in, 331–333
 - uric acid level in, 1186–1188, 1189–1191
 - vitamin B₁₂ and, 1218–1219
 - WBC and differential in, 399–403
- Polydipsia**
 - osmotic concentration and, 900–902
 - psychogenic, 129–130
- Polyendocrine autoimmune syndrome**, 748–749
- Polyhydramnios**, 792–795
- Polymorphonuclear cell**, 398
- Polymyalgia rheumatica**, 205, 485
- Polymyositis**
 - aldolase levels in, 18–19
 - antinuclear and Jo-1 antibodies in, 106–108
 - electromyography for, 566–567
 - muscle biopsy for, 205–208
 - myoglobin levels in, 894–895
 - skeletal muscle CK-MM and, 474–475
- Polyp**
 - barium enema for, 157–159
 - barium swallow for, 160–162
 - capsule endoscopy for, 274–276
 - colonoscopy for, 347–350, 425–429
 - cystoscopy for, 524–526
 - fecal analysis for, 603–604
 - gastrointestinal blood loss scan, 651–654
 - proctosigmoidoscopy for, 986–988
 - ultrasonography for, 1148–1149
 - upper GI series for, 1172–1174
- Poppy seed**, 546
- Porphyria**
 - acute, 41–43. *See also* Acute intermittent porphyria
 - apolipoprotein B and, 141–143
 - blood gas analysis in, 226–232
 - carbon dioxide levels in, 277–279
 - D-aminolevulinic acid levels in, 41–43
 - hexosaminidase level in, 705–706
 - LDLC level in, 327–329
 - porphyrin levels in, 960–962
 - symptomatic, 705–706
 - TBG in, 1097–1099
 - total cholesterol level in, 330–333

- Porphyrin, 959–962
 Portal hypertension
 abdominal laparoscopy for, 782–785
 liver and spleen scan for, 801–803
 Positron emission tomography (PET), 598
 of brain, 962–966
 of heart, 966–970
 of pelvis, 970–973
 Postanesthesia period, 767–770
 Post-cardiac vascular surgery, 457–458
 Postdialysis period, 265–267
 Postgastrectomy, 659–662
 Post-gastric surgery period, 643–645
 Posthemorrhagic anemia, 379–382
 Posthemorrhagic hematopoiesis, 174–177
 Post-membranoproliferative glomerulonephritis, 357–358
 Post-myocardial infarction syndrome, 932–934
 Postnatal umbilical cord sampling, 1256
 Postoperative period. *See* Postsurgical period
 Postpancreatectomy period, 655
 Postprandial glucose, 657
 Post-radiation therapy period, 643–645
 Post-streptococcal glomerulonephritis
 cryoglobulin detection in, 485–486
 kidney biopsy for, 191–194
 Post-streptococcal infection, 357–358
 Postsurgical period
 alpha₁-antitrypsin levels in, 138–139
 amylase levels in, 52–53
 biliary leak in, 701–704
 cholangiography in, 318–321
 direct antiglobulin testing (DAT) for, 457–458
 D-xylose tolerance test for, 547–550
 ileus in, 643–645
 ionized calcium values in, 265–267
 iron level in, 762–764
 plasminogen levels in, 946–947
 platelet count in, 379–382
 sodium levels and, 1068–1071
 urine urea nitrogen level during, 1180–1182
 Post-transfusion period, 265–267
 Potassium, 639–642. *See also*
 Hyperkalemia; Hypokalemia
 blood gas analysis of, 227–232
 in blood specimen, 974–978
 in urine specimen, 978–982
 Potassium imbalance, 595–597
 Pottery, lead in, 789–791
 PR (progesterone receptor) assays
 in breast cancer, 177, 178
 P-R interval, 559–561
 PRA (plasma renin activity), 1035–1039
 Pravastatin, 539
 Prealbumin, 982–984. *See also* Albumin (Alb)
 Precautions
 standard, 1285–1287
 transmission-based, 1277–1279
 Precocious puberty, 629–631
 Prediabetes glucose tolerance test, 665
 Prednisone, 825–828
 Pre-eclampsia
 alanine aminotransferase levels in, 13–15
 albumin/globulin ratio, 16–18
 D-dimer and, 539
 fibrin degradation product and, 618–619
 immunoglobulin E level in, 737–738
 microalbumin and, 877–879
 protein levels in, 1004–1006
 urinary calcium levels in, 269–271
 vitamin B₆ and, 1228
 Pregnancy
 abdominal laparoscopy and, 782–783
 ACTH levels in, 10
 albumin/globulin ratio, 16–18
 aldosterone levels in, 20–22
 alkaline phosphatase levels in, 24–26
 alpha₁-antitrypsin levels in, 138–139
 amniotic fluid analysis during, 47–51
 amylase levels with, 52–53
 apolipoprotein B and, 141–143
 blood creatinine clearance test and, 478–479
 BUN level during, 1178–1180
 calcitonin stimulation test for, 257–259
 carcinoembryonic antigen and, 282–285
 ceruloplasmin levels in, 299–300
 cholinesterase enzyme during, 1031–1032
 chromosome analysis during, 333–336
 complement protein levels in, 357–358
 copper levels in, 462–463
 cortisol levels in, 465–467
 CRP assay for, 471–472
 cystometry and, 521
 cystoscopy and, 524
 D-dimer and, 539
 DHEAS and, 542–543
 erythrocyte sedimentation rate and, 577–578
 erythropoietin level in, 581–582
 extrauterine, hysterosalpingography for, 728–730
 fetal fibronectin and, 611–612

- fibrinogen level in, 620–622
- folate level in, 627–628
- follicle-stimulating hormone level in, 630–631
- free thyroxine level during, 1100–1101
- free triiodothyronine levels in, 1112–1113
- gallium scan and, 636
- gastroesophageal reflux scan and, 648–649
- glucose tolerance test for, 666–669
- glycated hemoglobin A_{1c} and, 673–674
- gynecologic laparoscopy and, 786
- hematocrit in, 369–372
- hemoglobin in, 374–378
- hepatobiliary scan and, 702
- hexosaminidase level in, 705–706
- human chorionic gonadotropin level in, 715–717
- immunoglobulin level with, 28, 737–738
- intravenous pyelography and, 756
- KUB study and, 771
- LAP levels in, 795–797
- LDLC level in, 327–329
- liver and spleen scan during, 801–802
- lung perfusion scan and, 805
- lung ventilation scan and, 808
- lymphangiography and, 819
- magnesium level and, 823–824
- mammography during, 862
- mediastinoscopy during, 868–869
- MRA and, 829
- MRI and, 833, 837, 841, 844, 848, 852, 856, 859
- myocardial perfusion heart scan and, 890
- osteocalcin levels during, 904–905
- parathyroid scan and, 923
- pelvic CT of, 433–437
- PET scan and, 967, 971
- plasminogen levels during, 946–947
- potassium levels during, 975–978
- proctosigmoidoscopy and, 986
- prolactin level during, 990
- protein level in, 996–998
- radioactive iodine uptake and, 1022
- radiography and, 1028
- RBC count in, 385–388
- renin value in, 1036–1039
- renogram and, 1040
- retrograde ureteropyelography and, 1046
- retrograde urethrography and, 1183
- skeletal muscle CK-MM and, 474–475
- sphincter muscle electromyography and, 568–570
- syphilis serology testing for, 1082–1083
- TBG level in, 1098–1099
- thyroid scan during, 1090
- TORCH panel and, 537
- total cholesterol level in, 331–333
- total triiodothyronine levels and, 1114–1116
- transferrin level in, 1106–1108
- triglyceride levels and, 1109–1111
- ultrasonography for, 1136–1139, 1156–1158
- upper GI series and, 1173
- urea breath test and, 1175
- urine urea nitrogen level during, 1181–1182
- uterine fibroid embolization and, 1199
- venogram and, 1208
- vertebroplasty and, 1212
- vitamin B₆ and, 1228
- vitamin B₁₂ and, 1218–1219
- voiding cystourethrography and, 527
- WBC and differential in, 399–403
- white blood cell scan and, 1231
- Prehepatic jaundice, 163–166
- Premature infant, 791
- Premature labor, 611–612
- Premature rupture of membranes (PROM)
 - amniotic fluid analysis in, 46
 - fetal fibronectin in, 611
 - L/S ratio in, 791
 - ultrasound biophysical profile in, 1136
- Premenstrual sodium retention, 1068–1071
- Prerenal azotemia, 1068–1071
- Primary adrenocortical hypofunction, 10
- Primary angle-closure glaucoma, 752–755
- Primary biliary cirrhosis
 - antimitochondrial/antismooth muscle antibody in, 101–102
 - osteocalcin levels and, 904–905
- Primary fibrinolysis, 620–622
- Primary gonadal dysfunction, 815–816
- Primary hyperaldosteronism, 254–255
 - aldosterone levels in, 20–22
 - renin value in, 1036–1039
- Primary hyperparathyroidism, 940–942
 - phosphorus levels in, 943–945
- Primary hypogonadism, 629–631
- Primary myopathy, 565–567
- Primary pulmonary hypertension, 254–255
- Primidone, 117–121

- Printing material, lead and, 789–791
- Pro-B-type natriuretic peptide, 254–255
- Procainamide, 86–92
- Proctitis, 347–350
- Proctosigmoidoscopy, 985–988
- Progesterone, 988–990
- Progesterone receptor (PR) assays, in breast cancer, 177, 178
- Progressive muscular dystrophy, 894–895
- Progressive systemic sclerosis
- antinuclear antibody and, 106–108
 - anti-Scl 70 and, 106–108
 - esophageal manometry for, 583
 - fecal fat and, 606–608
- Proinsulin C-peptide, 467
- Prolactin, 990–993
- Prolapse, 551–554
- Proliferating cell nuclear antigen (PCNA), in breast cancer, 177, 178
- Proline, 40–41
- PROM (premature rupture of membranes)
- amniotic fluid analysis in, 46
 - fetal fibronectin in, 611
 - L/S ratio in, 791
 - ultrasound biophysical profile in, 1136
- Propionyl coenzyme A carboxylase deficiency, 767–770
- Prostate. *See also* Prostatic *entries*
- cystoscopy and, 523–526
 - ultrasonography of, 1158–1160
- Prostate abscess, 1159–1160
- Prostate cancer
- AcP levels in, 4
 - PSA levels and, 994–995
 - skeletal muscle CK-MM and, 474–475
 - total cholesterol level in, 330–333
 - ultrasonography for, 1159–1160
- Prostate-specific antigen (PSA), 993–995
- Prostatic acid phosphatase (AcP), 3–4
- Prostatic biopsy, 208–211
- Prostatic enlargement/hyperplasia
- cystoscopy in, 523–526
 - intravenous pyelography for, 756–758
 - PSA levels and, 994–995
 - retrograde ureteropyelography for, 1046–1048
 - ultrasonography for, 1159–1160
 - voiding cystourethrography for, 527–529
- Prostatic infarct
- AcP levels in, 4
 - PSA levels and, 994–995
- Prostatitis
- AcP levels in, 4
 - infertility and, 109–110
 - PSA levels and, 994–995
 - ultrasonography for, 1159–1160
- Prosthetic valve function
- echocardiography for, 551–554
 - transesophageal echocardiography of, 555–557
- Protective apparel, 1281
- Protective equipment, personal, 1280–1281
- Protein
- blood creatinine clearance test and, 478–479
 - blood, total, and fraction, 995–998
 - cortisol and, 464
 - drug interaction and, 1004–1005
 - excessive, BUN level and, 1178–1180
 - in urine specimen, 1194
 - levels by age, 996
 - urine, 1003–1006
 - urine urea nitrogen level and, 1180–1182
- Protein C, 999–1001
- Protein deficiency
- aPTT in, 926–929
 - BUN level in, 1178–1180
 - potassium levels and, 976–978
- Protein depletion, 765–766
- Protein diet, 767–770
- Protein fraction, 996
- Protein fractionation, 1003
- Protein malnutrition
- iron level in, 762–764
 - vitamin A and, 1228
 - vitamin B₁₂ and, 1218–1219
- Protein S, 1001–1003
- Protein-losing enteropathy, 996–998
- Proteus*, 494–497, 512–514
- Proteus* spp., 494–497
- Prothrombin, 1224
- Prothrombin time, 1007–1011
- Protoporphyrin, 575
- Protoporphyrin, 575
- Provider-performed microscopy, 1273
- Prussian blue stain, 691–693
- PSA (prostate-specific antigen), 993–995
- Pseudoaneurysm, 1129–1131
- Pseudocholinesterase, 1011–1012, 1030
- Pseudocyst
- amylase levels in, 52–53
 - lipase levels in, 797–799
 - pancreatic CT of, 429–433
 - ultrasonography for, 1153–1154
- Pseudogout
- arthroscopy of, 147–149
 - parathyroid hormone levels in, 921–922
 - synovial fluid analysis and, 1078–1080
- Pseudohypoparathyroidism
- calcitonin stimulation test for, 257–259

- ionized calcium values in, 265–267
- parathyroid hormone levels in, 921–922
- phosphorus levels and, 943–945
- phosphorus levels in, 940–942
- urinary calcium levels in, 269–271
- Pseudomonas*, 512–514
- Pseudomonas aeruginosa*
 - bacterial culture for, 494–497
 - bacterial pneumonia and, 502
- Pseudomyxoma peritonei, 855–857
- Pseudopregnancy, 615–617
- Psittacosis, 1081–1083
- Psoriasis
 - DHEAS and, 542–543
 - uric acid level in, 1186–1188
- Psoriatic arthritis, 721–722
- Psychiatric illness, 1102–1104
- Psychogenic polydipsia, 129–130
- Psychosis
 - aldolase levels in, 18–19
 - DHEAS and, 542–543
 - evoked brain potentials in, 591–594
 - FDG-PET scan for, 598–601
 - PET scan for, 963–966
- Ptosis of eye, 1215–1217
- Puberty, 629–631, 1084
- Pulmonary. *See also* Lung *entries*
- Pulmonary angiography, 74–77
- Pulmonary artery abnormality
 - coronary angiography of, 70–73
 - MRI for, 844–846
- Pulmonary artery agenesis
 - MRI for, 844
- Pulmonary atresia, 844–846
- Pulmonary carcinoma. *See also* Lung cancer
 - angiotensin-converting enzyme in, 83
 - cancer antigen levels in, 284–285
- Pulmonary compliance, 950, 951, 1015
- Pulmonary disability, 1015–1017
- Pulmonary disease. *See also specific conditions, e.g.*, Pneumonia
 - apolipoprotein B and, 141–143
 - bronchoscopy for, 250–253
 - calcium values in, 260
 - chest x-ray and, 301
 - chronic obstructive. *See* Chronic obstructive pulmonary disease (COPD)
 - LDLC level in, 327–329
 - lung biopsy for, 198
 - lung perfusion scan in, 804
 - plethysmography for, 951–954
 - proctosigmoidoscopy and, 986
 - pulmonary function study for, 1015–1017
 - sputum cytology in, 530
 - sweat chloride values in, 311
 - total cholesterol level in, 331–333
 - ZZ deficiency in, 137
- Pulmonary drug regimen, pulse oximetry and, 1018
- Pulmonary edema, 30–32
 - A/a gradient and a/A ratio in, 30
 - blood gas analysis in, 226–232
 - PET scan and, 967
 - skeletal muscle CK-MM and, 474–475
- Pulmonary effusion
 - lung perfusion scan in, 804
 - lung ventilation scan in, 808
- Pulmonary embolism, 30–32
 - A/a gradient and a/A ratio in, 30
 - alkaline phosphatase levels in, 25–26
 - antithrombin III levels in, 135–136
 - blood gas analysis in, 226–232
 - D-dimer and, 539
 - erythrocyte sedimentation rate and, 577–578
 - fibrin degradation product and, 618–619
 - lactic acid levels and, 777–779
 - lung perfusion scan for, 805–807
 - lung ventilation scan for, 807–810
 - phosphorus levels in, 940–942
 - proctosigmoidoscopy and, 986
 - pulmonary angiography of, 74–77
 - skeletal muscle CK-MM and, 474–475
 - thoracic CT for, 454–456
 - ultrasonography for, 1169
 - venography of, 1208
- Pulmonary eosinophilia, 573–575
- Pulmonary failure, 777–779
- Pulmonary fibrosis, 30–32
 - A/a gradient and a/A ratio in, 30
 - angiotensin-converting enzyme in, 83
 - chest x-ray for, 302–303
 - erythropoietin level in, 581–582
 - pulmonary function study for, 1016–1017
- Pulmonary function study, 1012–1017
- Pulmonary hemosiderosis, 99–100
- Pulmonary hypertension, 254–255, 805–807
- Pulmonary infarction
 - alkaline phosphatase levels in, 25–26
 - aspartate aminotransferase levels in, 150–152
 - electrocardiogram for, 559–561
 - lactate dehydrogenase levels in, 775–776
 - pleural fluid analysis and, 956–958
- Pulmonary infection
 - bronchoscopy for, 250–253
 - Mycobacterium avium intracellulare* in, 488
 - Mycobacterium tuberculosis* in. *See* Pulmonary tuberculosis

Pulmonary infection (*continued*)
 plethysmography for, 951–954
 sweat chloride values in, 311–314

Pulmonary neoplasm. *See also* Lung cancer
 amylase levels in, 52–53
 chest x-ray for, 301–303
 function study and, 1016–1017
 growth hormone levels and, 683–684

Pulmonary scan, 804–807

Pulmonary sequestration, 74–77

Pulmonary tuberculosis
 antidiuretic hormone and, 129–130
 blood gas analysis in, 227–232
 copper levels in, 462–463
 pleural fluid analysis and, 956–958
 zinc level in, 1235–1236

Pulse oximetry, 1018–1020

Punch biopsy, 182–185, 212–214

Pupil dilation, 1033

Purine, 1186–1188, 1189–1191

Purkinje fiber, 558

Pus, 514–516

Pyelography, intravenous, 755–758

Pyelonephritis
 BUN level in, 1178–1180
 haptoglobin level in, 686–687
 intravenous pyelography for, 756–758
 kidney biopsy for, 191–194
 renogram for, 1040–1042
 ultrasonography for, 1145–1147
 urine creatinine clearance test and, 482–484

Pylori breath test, 1175–1177

Pyloric obstruction, 645–647

Pyloric stenosis, 274–276

Pycele, 1161–1163

Pyridoxal phosphate deficiency, 13–15

Pyridoxal-5-phosphate, 1226

Pyridoxine deficiency, 910–912

Pyrophosphate (PYP) cardiac scan, 750–752

Pyrophosphate (PYP) uptake, 885

Pyrosis, 583

Pyroxidine, 1226

Pyruvate kinase (PK), 1020

Pyruvate kinase deficiency, 902–903

Q

QRS complex, 559–561

Quad-marker testing, 613, 715

QuantiFERON-TB Gold (QFT-G) blood test, 1119–1121

Quantitative computed tomography (QCT), 242–245

Quinidine, 86–92

R

Rabies virus, 517–519

Radial arterial puncture, 1256, 1259–1260

Radial scar, 1143–1147

Radiation necrosis, 963–966

Radiation therapy
 beta₂-microglobulin and, 881
 bone marrow biopsy during, 174–177
 cancer antigen levels in, 284–285
 erythropoietin level and, 581
 folate levels and, 627
 gastric emptying scan and, 643
 human growth hormone and, 683
 immunofixation electrophoresis and, 731
 immunoglobulin level with, 28, 738
 renin value and, 1037
 semen analysis and, 1058
 uric acid level in, 1186–1188
 vitamin D and, 1221
 WBC and differential in, 400–403

Radiculopathy, 566–567

Radioactive iodine uptake (RAIU), 1021–1023

Radioactive perfusion scan, 804–807

Radioactive scan
 renin value and, 1037
 vanillylmandelic acid level and, 1203
 vitamin D and, 1221

Radioactive seed, planting, 524–526

Radioactive ventilation scan, 807–810

Radioallergosorbent test (RAST), 26–28

Radiofrequency ablation (RFA), 1024–1027

Radiographic absorptiometry, 242–245

Radiography
 cystoscopy and, 523
 skeletal, 1027–1029

Radionuclide hypersensitivity, 890

Radionuclide scan, 1163
 of bone, 245–248
 of liver, 800–803
 of lung, 804–807

RAIU (radioactive iodine uptake), 1021–1023

Rapid plasma reagin (RPR), 1081

RAST (radioallergosorbent test), 26–28

Raynaud's syndrome
 antinuclear antibody and, 106–108
 cold agglutinin titer levels in, 342–343
 cryoglobulin detection in, 485–486
 lupus anticoagulant antibody and, 811–813
 plethysmography for, 950–954, 951–954
 ultrasonography for, 1129–1131

- RDS. *See* Respiratory distress syndrome (RDS)
- RDW (red blood cell distribution width), 388–391
- Receptor assays, in breast cancer, 177, 178
- Receptor-positive tumor, 179–181
- Rectal electromyography, 568–570
- Rectal prolapse, proctosigmoidoscopy for, 986–988
- Rectal tumor, 1159–1160
- Rectum, 985–988
- Red blood cell(s). *See also* Erythrocyte entries
- aplasia of, 930–931, 1043–1044
 - bilirubin levels in, 164–166
 - complete blood count and, 363, 383–388
 - direct antiglobulin testing (DAT) of, 457
 - in urine specimen, 1195
 - iron and, 764
 - life span of, 672
 - osmotic fragility and, 902–903
 - surface antigens on, 233
 - trauma to, hemosiderin and, 692–693
- Red blood cell cholinesterase, 1030–1032
- Red blood cell count, 384–388
- Red blood cell distribution width (RDW), 388–391
- Red blood cell inclusions, 364
- Red blood cell indices, 363, 388–391
- Red blood cell morphology, 363–364, 391–396
- Reflux
- gastroesophageal. *See* Gastroesophageal reflux (GER) vesicoureteral, 527–529
- Refraction, 1032–1035
- Refractive error, 1032–1035
- Refractive surgery, 913
- Refractory anemia, 393–396
- Regional enteritis, 627–628
- Regional hypoventilation, 808–810
- Regurgitation
- echocardiography for, 551–554
 - upper GI series for, 1172–1174
- Reifenstein's syndrome, 629–631
- Reiter's syndrome
- human leukocyte antigen and, 721–722
- Rejection, organ transplant, 740–742
- Relapsing fever, 1081–1083
- Renal absorption, 825–828
- impaired, 940–942
- Renal angiography, 78–82
- Renal anomaly/abnormality, 771–772
- intravenous pyelography for, 756–758
 - retrograde ureteropyelography for, 1045–1048
- Renal artery aneurysm, 79–82, 442–445
- Renal artery embolism, 1039–1042
- Renal artery stenosis, 1039–1042
- Renal biopsy, 191
- Renal calculi
- abdominal CT of, 404–407
 - blood creatinine clearance test and, 477–479
 - cystoscopy for, 524–526
 - formation of, 271–272
 - intravenous pyelography for, 756–758
 - kidney CT for, 442–445
 - KUB study for, 771–772
 - magnesium and, 825
 - panel for, 271–272
 - retrograde ureteropyelography for, 1045–1048
 - sodium levels and, 1068–1071
 - ultrasonography for, 1145–1147
- Renal cancer
- calcium values in, 261–263
 - kidney CT for, 442–445
- Renal cell, 1195
- Renal cell carcinoma, 442–445
- Renal contusion, 1040–1042
- Renal cyst, 79–82
- intravenous pyelography for, 756–758
 - kidney CT for, 442–445
 - ultrasonography for, 1145–1147
- Renal damage, 1189–1191
- Renal defect, 1136–1139
- Renal dialysis
- beta₂-microglobulin levels in, 880–883
 - copper levels in, 462–463
 - vitamin B₆ and, 1228
- Renal disease, 346–350
- amino acid levels in, blood test for, 37–38
 - amylase levels in, 52–53
 - beta₂-microglobulin levels in, 880–883
 - bleeding time in, 220
 - blood creatinine clearance test and, 477–479
 - blood gas analysis in, 227–232
 - cyclic antidepressants and, 127–128
 - erythropoietin level in, 581–582
 - fibrin degradation product and, 618–619
 - glucose levels in, 659–662
 - 5-hydroxyindoleacetic acid level in, 725–726
 - lactate dehydrogenase levels in, 775–776
 - microalbumin and, 877–879

- Renal disease (*continued*)
 osmolality and, 899–902
 polycystic. *See* Polycystic kidney disease
 RBC count in, 385–388
 renal angiography and, 78–82
 reticulocyte count for, 1043–1044
 retrograde ureteropyelography for, 1045–1048
 sodium levels and, 1068–1071
 total iron-binding capacity and, 765–766
 transferrin level in, 1106–1108
 uric acid level in, 1186–1188
 urinary calcium levels in, 269–271
 urine urea nitrogen level in, 1180–1182
 vitamin A and, 1227
- Renal dysfunction. *See also* Renal failure;
 Renal insufficiency
 magnesium level and, 825–828
 MRI and, 856
- Renal dysplasia, 1039–1042
- Renal failure, 84–86, 254–255. *See also*
 Renal insufficiency
 amino acid levels in, blood test for, 37–38
 amino acid levels in, urine test for, 40
 apolipoprotein A and B, 141–143
 blood creatinine clearance test and, 477–479
 blood gas analysis in, 227–232
 BUN level in, 1178–1180
 calcitonin stimulation test for, 257–259
 carbon dioxide levels in, 278–279
 chloride values in, 307–310, 312–314
 C-peptide levels in, 468–469
 erythropoietin level in, 581–582
 gastrin stimulation test for, 645–647
 glucagon level in, 655–657
 glycated hemoglobin A_{1c} and, 673–674
 HDL and LDL levels in, 326–329
 homocysteine level and, 710–711
 human growth hormone levels in, 683–684
 hyperlipoproteinemia and, 800
 lipase levels in, 797–799
 magnesium level and, 825–828
 myoglobin levels in, 894–895
 osteocalcin levels and, 904–905
 phosphorus levels in, 940–942
 potassium levels and, 975–978, 980–982
 prealbumin and, 983–984
 prolactin level in, 991–993
 radioactive iodine uptake and, 1022–1023
 renogram for, 1040–1042
 retrograde ureteropyelography and, 1046
 total cholesterol level in, 330–333
 triglyceride levels and, 1109–1111
 uterine fibroid embolization and, 1200
 venogram and, 1208
 vitamin B₁₂ and, 1218–1219
 voiding cystourethrography and, 527
- Renal function, 547–550
- Renal hematoma
 intravenous pyelography for, 756–758
 KUB study for, 771–772
- Renal hypertrophy, 1145–1147
- Renal infarction, 1039–1042
- Renal infectious disease, 1040–1042
- Renal inflammatory disease, 1040–1042.
See also Glomerulonephritis;
 Nephritis; Pyelonephritis
- Renal insufficiency. *See also* Renal failure
 intravenous pyelography and, 756
 magnesium level and, 822–824
 MRI and, 833, 852
 retrograde ureteropyelography and, 1046
- Renal obstruction, 1045–1048
- Renal osteodystrophy
 bone scan for, 245–248
 osteocalcin levels and, 904–905
 urinary calcium levels in, 269–271
- Renal pelvis, 755–758
- Renal perfusion, 1178–1180
- Renal transplantation
 antithrombin III levels in, 135–136
 calcium values in, 261–263
 fibrin degradation product and, 618–619
 GGT levels in, 670–672
 glucagon level after, 654–655
 kidney biopsy for, 191–194
 renogram for, 1040–1042
 ultrasonography for, 1145–1147
- Renal trauma, 1040–1042
 KUB study for, 771–772
- Renal tubular acidosis
 blood gas analysis in, 227–232
 chloride values in, 308–310
 phosphorus levels in, 940–942, 943–945
 potassium levels and, 976–978
 sodium levels and, 1068–1071
 urinary calcium levels in, 268–271
- Renal tubular defect, 940–942
- Renal tubular disease, 261–263
- Renal tumor
 calcium values and, 261–263
 intravenous pyelography for, 756–758

- renin value in, 1036–1039
 - ultrasonography for, 1145–1147
- Renal vein thrombosis
 - kidney biopsy in, 191
 - MRI for, 833
 - renogram for, 1040
- Renin, 20–22, 1035–1039
- Renin-angiotensin system, 1035–1039
- Renogram, 1039–1042
- Renovascular hypertension, 1036–1039
- Replacement therapy, 1234–1236
- Reproductive system, 1248
- Residual volume, 1013
- Respirators, 1281
- Respiratory acidosis
 - blood gas analysis in, 225, 227
 - carbon dioxide levels in, 277–279
 - chloride values in, 308–310
 - phosphorus and, 940–942
- Respiratory alkalosis
 - phosphorus and, 940–942
- Respiratory alkalosis
 - blood gas analysis in, 225, 227
 - carbon dioxide and, 278
 - chloride values in, 308–310
- Respiratory depression
 - blood gas analysis in, 226–232
 - carbon dioxide levels in, 277–279
 - heroin and, 546
- Respiratory disease, 783
- Respiratory disorder, 1276
- Respiratory distress syndrome (RDS)
 - A/a gradient and a/A ratio in, 30
 - amniotic fluid analysis for, 48–51
 - blood gas analysis in, 227–232
 - premature infant and, 791
 - triglyceride levels and, 1109–1111
- Respiratory failure
 - blood gas analysis in, 227–232
 - viral culture for, 517–519
- Respiratory infection
 - phosphorus levels in, 940–942
 - pulmonary function study for, 1016–1017
- Respiratory syncytial virus (RSV), 517–519
- Respiratory system
 - laboratory and diagnostic tests for, 1249
 - lead and, 789
 - pulmonary function study of, 1012–1017
- Respiratory tract infection, upper, 518–519
- Restrictive pulmonary disease, 951–954
- Retained antrum syndrome
 - gastric acid stimulation test and, 639–642
 - gastrin stimulation test for, 645–647
- Retardation
 - intrauterine growth, 792–795
 - mental, 48–51
- Reticulocyte, 663, 1042–1044
- Reticulocyte production index (RPI), 1043
- Retinal detachment, 1215–1217
- Retinal edema, 623–625
- Retinal exudate, 1215–1217
- Retinal hemorrhage, 1215–1217
- Retinal occlusion, 1215–1217
- Retinal pathology, 351–352
- Retinitis pigmentosa, 1215–1217
- Retinol, 1226
- Retinopathy, 623–625, 634–635
- Retrobulbar neuritis, 591–594
- Retrograde pyelography, 523
- Retrograde ureteropyelography, 1045–1048
- Retrograde urethrography, 1183–1185
- Retroperitoneal lymphadenopathy, 426–429
- Retroperitoneal lymphoma, 819–821
- Retroperitoneum, 1150–1152
- Retrovirus, 695
- Reverse grouping, 233
- Reye's syndrome
 - amino acid levels in, blood test for, 37–38
 - ammonia levels in, 44–45
 - apolipoprotein B and, 141–143
 - aspirin and, 54
 - brain/lung CK-BB and, 474–475
 - lactic acid levels and, 777–779
 - LDLC level in, 327–329
 - liver biopsy for, 195–197
- Rh immune globulin, 773
- Rh incompatibility, 459–460
- Rhabdomyolysis
 - blood creatinine clearance test and, 478–479
 - myoglobin levels in, 894–895
 - skeletal muscle CK-MM and, 474–475
- Rheumatic disease
 - albumin/globulin ratio, 16–18
 - complement protein levels in, 357–358
- Rheumatic fever
 - antistreptolysin O antibody in, 111
 - copper levels in, 462–463
 - CRP assay for, 471–472
 - erythrocyte sedimentation rate and, 577–578
 - Gram stain for, 680–681
 - platelet count in, 379–382
 - WBC and differential in, 400–403
- Rheumatoid arthritis, 1049
 - amino acid levels in, blood test for, 37–38

Rheumatoid arthritis (*continued*)

- angiotensin-converting enzyme in, 83
 - anti-CCP antibodies as test for, 96–98
 - antimitochondrial/antismooth muscle antibody in, 101–102
 - antineutrophilic cytoplasmic antibodies in, 103–104
 - antinuclear antibody and, 106–108
 - arthroscopy of, 147–149
 - bone scan for, 245–248
 - ceruloplasmin levels in, 299–300
 - complement protein levels in, 357–358, 359–360
 - copper levels in, 462–463
 - CRP assay for, 471–472
 - cryoglobulin detection in, 485–486
 - eosinophil count in, 573–575
 - erythrocyte sedimentation rate and, 577–578
 - human leukocyte antigen and, 721–722
 - immunoglobulin E level in, 737–738
 - juvenile, 721–722
 - lupus anticoagulant antibody and, 811–813
 - myoglobin levels in, 894–895
 - platelet antibody and, 948–949
 - platelet count in, 379–382
 - rheumatoid factor and, 1049–1050
 - Schirmer tear test for, 1055–1056
 - synovial fluid analysis and, 1078–1080
 - WBC and differential in, 400–403
- Rheumatoid disease
- pericardial fluid analysis for, 932–934
 - pleural fluid analysis and, 956–958
 - vitamin C and, 1228
- Rheumatoid factor, 1049–1050
- cytomegalovirus and, 537
 - D-dimer and, 539
- Rheumatoid spondylitis, ankylosing
- copper levels in, 462–463
 - human leukocyte antigen and, 721–722
 - MRI in, 848
 - radiography in, 1028
 - spine CT in, 446
- Rhinitis
- eosinophil count in, 573–575
 - immunoglobulin E level in, 734–735
 - immunoglobulin levels in, 27–28
- Rhinovirus, 518–519
- RhoGAM, 234, 773
- Rhophylac, 773
- Ribonucleic acid (RNA), 102–104
- Ribonucleoprotein antigen, 104–108
- Ricketts
- alkaline phosphatase levels in, 24–26

- amino acid levels in, urine test for, 40
- urinary calcium levels in, 269–271
- vitamin D and, 1220–1222
- WBC and differential in, 400–403

Rickettsia, 816

- Rickettsial disease, 1081–1083
- Right upper quadrant, pain in, 1147–1149
- Rigid bronchoscopy, 252
- Riley-Day syndrome, 712–714
- Rinne test, 1122–1124
- RNA (ribonucleic acid), 102–104
- Rocky Mountain spotted fever, 380–382
- Rotator cuff
 - arthroscopic evaluation of, 147
 - MRI of, 848
- Rotavirus, 517–519
- Rouleaux, 364, 392, 577
- Rubella antibody, 1051–1053
- Rubella virus, 517–519
- Rubeola antibody, 1053–1054
- Ruptured viscus, 771–772
- RUQ (right upper quadrant), pain in, 1147–1149

S

Salicylate intoxication

- blood gas analysis in, 227–232
- carbon dioxide levels in, 278–279
- chloride values in, 308–310
- phosphorus levels in, 940–942

Saline, excessive infusion

- chloride values in, 307–310
- sodium levels in, 1065–1067

Saliva, 883

Salmonella, 506–509

Salmonellosis, 603–604

Salpingitis, 786–788

Salt-losing nephritis, 308–310

Sandhoff's disease, 705–706

Saponification, 265

Sarcoidosis

- alkaline phosphatase levels in, 24–26
- angiotensin-converting enzyme in, 83
- beta₂-microglobulin levels in, 880–883
- blood gas analysis in, 227–232
- calcium values in, 261–263
- cryoglobulin detection in, 485–486
- electromyography for, 566–567
- eosinophil count in, 573–575
- immunoglobulin E level in, 737–738
- liver and spleen scan for, 801–803
- liver biopsy for, 194–197
- lung biopsy for, 198–201
- lung ventilation scan for, 808–810
- lymph node biopsy for, 202–205
- mediastinoscopy for, 868–871

- oxalate levels in, 910–912
- parathyroid hormone levels in, 921–922
- protein level in, 996–998
- pulmonary angiography of, 74–77
- pulmonary function study for, 1016–1017
- rheumatoid factor and, 1049–1050
- urinary calcium levels in, 268–271
- vitamin D and, 1220–1222
- WBC and differential in, 400–403
- Sarcoma
 - barium enema and, 157–159
 - urinary calcium levels in, 268–271
- Sarcosine, 40–41
- Scarlet fever
 - antistreptolysin O antibody in, 111
 - Gram stain for, 680–681
 - syphilis serology testing for, 1081–1083
- Scheie's classification, 676
- Schiller's test, 182–185
- Schirmer tear test, 1055–1056
- Schistocyte, 363, 392
- Schistosoma haematobium* infection, 908–909
- Schistosoma japonicum* infection, 908–909
- Schistosoma mansoni* infection, 908–909
- Schistosomiasis, 908–909
 - D-xylose tolerance test for, 547–550
 - immunoglobulin levels with, 28
 - urinary calcium levels in, 269–271
- Schizophrenia
 - aldolase levels in, 18–19
 - FDG-PET scan for, 598–601
 - PET scan for, 963–966
- Schizotypal personality disorder, 712–714
- Schwabach test, 1122–1125
- Schwartz syndrome, 676–677
- Scintigraphy, 4–7
- Scleritis, 1062–1064
- Scleroderma, 106–108
 - D-xylose tolerance test for, 547–550
 - esophageal manometry for, 583
 - gastric emptying scan for, 643–645
 - rheumatoid factor and, 1049–1050
 - skin biopsy for, 212–214
- Sclerosing cholangitis
 - antineutrophilic cytoplasmic antibodies in, 103–104
 - ERCP in, 321–324
 - percutaneous transhepatic cholangiography in, 315–318
- Scoliosis
 - chest x-ray for, 302–303
 - pulmonary function study for, 1016–1017
- Scrotum, 1161–1163
- Scurvy
 - alkaline phosphatase levels in, 25–26
 - folate level in, 627–628
 - vitamin C and, 1227, 1228
- Seborrheic keratosis, 212–214
- Secondary fibrinolysis, 539–541
- Secondary glaucoma, 752–755
- Secondary polycythemia, 384–388
- Sedative, 563
- Sedentary lifestyle
 - cardiac scoring for, 421–424
 - creatine kinase and, 474–475
- Seizure disorder, 1228
 - EEG determining, 563–564
 - PET scan for, 963–966
- Semen analysis, 1057–1059
- Seminal vesicle, 1158–1160
- Seminal vesicle tumor, 1159–1160
- Sensorimotor neuropathy, 591–594
- Sensorineural hearing loss, 1071–1073
- Sepsis
 - ACTH levels in, 10
 - bacterial culture for, 498–501
 - ionized calcium values in, 265–267
- Septal defect
 - coronary angiography of, 70–73
 - echocardiography for, 551–554
 - lung perfusion scan and, 805
 - myocardial perfusion heart scan for, 890–893
 - transesophageal echocardiography of, 555–557
- Septic shock, 10
- Septicemia
 - bacterial culture for, 498–501
 - cystoscopy and, 524
 - WBC and differential in, 400–403
- Serial skeletal x-ray, 1027–1029
- Serine, 40–41
- Serotonin, 724
- Serous fluid, 931, 935, 954
- Sestamibi scan, 888
- Sexually transmitted diseases (STDs), 493–497
- SGOT (aspartate aminotransferase), 149–152
- SGPT (alanine aminotransferase), 13–15
- Shaffer's classification, 676
- Shaving biopsy, 212–214
- Sheehan's syndrome, 991–993
- Shellfish allergy
 - hysterosalpingography and, 728
 - intravenous pyelography and, 756
 - retrograde ureteropyelography and, 1046
 - retrograde urethrography and, 1183
 - uterine fibroid embolization and, 1200

- Shellfish allergy (*continued*)
 venogram and, 1208
 vertebroplasty and, 1212
 voiding cystourethrography and, 527
- Shift to the left, 373, 398, 573–575
- Shift to the right, 373
- Shigella*, 506–509
- Shigellosis, 603–604
- Shingles, 1206
- Shock
 alanine aminotransferase levels in, 13–15
 amino acid levels in, 37–38
 aspartate aminotransferase levels in, 150–152
 asthmatic, 277–279
 blood creatinine clearance test and, 478–479
 blood gas analysis in, 227–232
 BUN level in, 1178–1180
 catecholamine levels in, 287–290
 glucose levels in, 659–662
 hematocrit in, 369–372
 hypoxic, 474–475
 lactate dehydrogenase levels in, 775–776
 lactic acid levels and, 777–779
 myoglobin levels in, 894–895
 plethysmography and, 952
 septic, 10
 urine creatinine clearance test and, 482–484
- Short luteal phase syndrome, 989–990
- Shoulder, MRI of, 847
- Shoulder
 blood gas analysis with, 227–232
 CT angiography of, 409–412
 echocardiography for, 551–554
 transesophageal echocardiography of, 555–557
- Sickle cell anemia
 AcP levels in, 4
 bone marrow biopsy for, 174–177
 cholinesterase enzyme in, 1030–1032
 erythrocyte sedimentation rate and, 577–578
 follicle-stimulating hormone level in, 630–631
 hemoglobin electrophoresis and, 689–691
 hemosiderin levels in, 692–693
 LAP levels in, 796–797
 MRI for, 848–850
 protein levels in, 1004–1006
 ultrasonography for, 1164–1166
 uric acid level in, 1186–1188, 1189–1191
- Sickle cell screen, 1060–1061
- Sickling hemoglobin, 1060
- Sideroblastic anemia
 erythrocyte protoporphyrin levels in, 576–577
 folate level in, 627–628
 iron level in, 762–764
 LAP levels in, 796–797
 RBC morphology in, 393–396
 reticulocyte count for, 1043–1044
 total cholesterol level in, 331–333
 total iron-binding capacity and, 765–766
- Siderophilin, 1106–1108
- Sigmoid torsion, 157–159
- Sigmoid volvulus, 157–159
- Sildenafil (Viagra), 890
- Silent disease, 344
- Single-energy x-ray absorptiometry (SXA), 242–245
- Single-photon emission computed tomography (SPECT), 885, 889
- Sinopulmonary disease, 737–738
- Sinusitis, 734–735
- Sjogren's syndrome
 antinuclear antibody and, 106–108
 Anti-SS-A/La and, 106–108
 cryoglobulin detection in, 485–486
 immunoglobulin E level in, 737–738
 rheumatoid factor and, 1049–1050
 Schirmer tear test for, 1055–1056
- Skeletal defect, 1136–1139
- Skeletal disorder, chest x-ray and, 301–303
- Skeletal fluorosis, 920–922
- Skeletal muscle CK-MM, 473–474
- Skeletal muscle injury, 894–895
- Skeletal x-ray, 1027–1029
- Skin
 bacterial culture of, 492–497
 fungal culture of, 514–516
- Skin biopsy, 212–214
- Skin disease
 albumin/globulin ratio in, 16–18
 protein level in, 996–998
 vitamin A and, 1227
- Skin infection, 566
- Skin test, 1118–1122
- Skull fracture/contusion, 837–839
- SLE. *See* Systemic lupus erythematosus (SLE)
- Sleep, 815
- Sleep apnea, 563–564, 1014
- Slit-lamp biomicroscopy, 1061
- Small airway disease, 1014
- Small bowel
 capsule endoscopy of, 273–276
 gastric emptying scan of, 642–645
- Small bowel ischemia, 547–550

- Small bowel resection
 5-hydroxyindoleacetic acid level and, 725–726
 vitamin B₁₂ and, 1218–1219
- Small bowel series, 1171–1174
- Small bowel tumor
 capsule endoscopy for, 274–276
 upper GI series for, 1172–1174
- Smear, 487–492
- Smoking, 595–597
 acquired methemoglobinemia and, 874
 apolipoprotein A and, 141–143
 blood gas analysis in, 227–232
 cancer antigen levels in, 284–285
 carbon dioxide levels in, 280–282
 cardiac scoring for, 421–424
 catecholamine level and, 1203
 FDG-PET scan imaging and, 599
 glucose levels and, 780
 glucose tolerance test and, 667–669
 HDL-C level in, 326–329
 PET scan and, 964, 967, 971
 plethysmography and, 951
 pulse oximetry and, 1018
 semen analysis and, 1058
 ultrasonography and, 1130
 vitamin C and, 1229
- Sodium. *See also* Hypernatremia;
 Hyponatremia
 in blood specimen, 1064–1067
 in urine specimen, 1068–1071
- Sodium depletion, 312–314
- Soft tissue, 1077
 MRI of, 847–850
- Soft-tissue abnormality, 1028–1029
- Soft-tissue mass
 intravenous pyelography for, 756–758
 KUB study for, 771–772
 mammography for, 862–864
 MRI for, 840–843, 855–857
- Somatosensory evoked response (SER), 590
- Somatostatinoma, 659–662
- Spasm, 583
- Specimen
 biopsy, 677–679
 blood. *See* Blood specimen
 cervical vaginal, semen analysis and, 1059
 clean-catch. *See* Clean-catch specimen; Urine specimen
 clotting, 949
 expectorated, 532
 fluid, 1263
 hemolyzed, 949
 icteric, 811
 lipemic, 811
 stool, 1263. *See also* Feces
 timed. *See* Timed specimen
 tissue, 1263
 urine. *See* Clean-catch specimen;
 Urine specimen
 Specimen quality, 577–578
 Spectrophotometry, 15–18
 Speech recognition threshold, spondee, 1071–1073
 Sperm motility, semen analysis for, 1057–1059
 Spermatocoele, 1161–1163
 Spermatogenesis, 1084
 S-phase fraction (SPF), in breast cancer, 177, 178
 Spherocyte, 364, 392
 Spherocytosis
 bone marrow biopsy for, 174–177
 erythrocyte sedimentation rate and, 577–578
 osmotic fragility and, 902–903
 RBC indices in, 389–391
 Sphincter electromyography, 520–523
 Sphincter muscle, 568–570
 Spina bifida, 446–449
 Spinal block, 182–185
 Spinal cord, 520–523
 Spinal cord compression, 446–449
 Spinal cord injury, 591–594
 Spinal cord ischemia, 409–412
 Spinal fracture, 1212
 Spinal stenosis
 electromyography for, 565–567
 MRI for, 848–850
 Spinal tumor, 446–449
 Spine
 computed tomography of, 445–449
 vertebroplasty of, 1211–1214
 Spine curvature, 1016–1017
 Spirometry, 1012–1017
 Spleen
 computed tomography of, 449–453
 iron storage in, 764–765
 trauma to, KUB study for, 771–772
 ultrasonography of, 1163–1166
 Spleen scan, 800–803
 Splenectomy
 eosinophil count in, 573–575
 platelet count in, 379–382
 Splenic infiltration, 450–453
 Splenic laceration
 abdominal CT of, 404–407
 splenic CT of, 450–453
 Splenic mass, 1164–1166
 Splénomegaly
 abdominal laparoscopy for, 782–785
 hematocrit in, 369–372

- Splenomegaly (*continued*)
- hemoglobin electrophoresis for, 689–691
 - hemoglobin in, 374–378
 - ultrasonography for, 1164–1166
- SpO₂ (arterial blood oxygen saturation), 1018–1020
- Spondee speech recognition threshold, 1071–1073
- Spondylitis, ankylosing rheumatoid
- copper levels in, 462–463
 - human leukocyte antigen and, 721–722
 - MRI in, 848
 - radiography in, 1028
 - spine CT in, 446
- Spondylosis
- MRI for, 848–850
 - spinal CT for, 446–449
- Spontaneous abortion, AFP levels in, 615
- Sporothrix schenckii*, 515–516
- Sprue, 627. *See also* Celiac disease; Tropical sprue
- Sputum
- bacterial culture of, 501–506
 - fungal culture of, 514–516
- Squamous cell, 1195
- Squamous cell carcinoma, 915–916
- calcium values in, 261–263
 - skin biopsy for, 212–214
- ST segment, 559–561
- ST segment depression, 595–597
- Standard gestational tolerance test, 665, 668
- Standard oral tolerance test, 665, 668
- Standard precautions, 1283, 1285–1287
- Standing, prolonged periods of, 975–978
- Staphylococcal sepsis, 357–358
- Staphylococcus, 501, 502
- Staphylococcus aureus*, 494–497
- Starvation. *See also* Malnutrition
- aldosterone levels in, 20–22
 - bilirubin levels in, 164–166
 - BUN level in, 1178–1180
 - carbon dioxide levels in, 278–279
 - glucose levels in, 659–662
 - ketone level in, 767–770
 - potassium levels and, 980–982
 - protein level in, 996–998
 - uric acid level in, 1186–1188
- Stature
- blood creatinine clearance test and, 478–479
 - creatinine kinase and, 474–475
- STDs (sexually transmitted diseases), 493–497
- Steatorrhea, 606
- Stein-Leventhal syndrome
- DHEAS and, 542–543
 - follicle-stimulating hormone level in, 630–631
 - prolactin level in, 991–993
- Stenosis
- barium enema for, 157–159
 - CT angiography of, 408–412, 409–412
 - echocardiography for, 551–554
 - ultrasonography for, 1126–1128, 1129–1131
- Stent placement, 58, 66
- Stereotactic biopsy, 1074–1077
- Sterile fluid, 514–516
- Sterility
- semen analysis for, 1057–1059
 - vitamin A and, 1228
- Steroid therapy
- ACTH levels in, 11
 - alpha₁-antitrypsin levels in, 138–139
 - haptoglobin level in, 686–687
 - LAP levels and, 796
 - prealbumin and, 983–984
- Steroid-induced diabetes, 748–749
- Stimulants, 563
- Stomach. *See also* Gastric *entries*
- capsule endoscopy of, 273–276
 - esophagogastroduodenoscopy of, 586–589
 - gastric emptying scan of, 642–645
 - upper GI series of, 1171
 - urea breath test of, 1175–1177
- Stomach biopsy, 1175
- Stomatocyte, 364, 392
- Stool. *See* Feces
- Stool antigen test, 1175
- Stool specimen, 1263. *See also* Feces
- Strabismus, 750–752
- Strep throat, 680–681
- Streptococcal antideoxyribonuclease-B, 122–124
- Streptococcal glomerulonephritis, 680–681
- Streptococcal screen, group A, 680–681
- Streptococcus, group B, culture for, 492, 493, 494
- Streptococcus pneumoniae*
- bacterial culture for, 494–497
 - bacterial pneumonia and, 502
- Streptococcus pyogenes*, 509–511
- Stress
- alpha₁-antitrypsin levels in, 138–139
 - antidiuretic hormone and, 129–130
 - apolipoprotein B and, 141–143
 - cardiac scoring for, 421–424
 - catecholamine level and, 1203
 - cortisol levels in, 465–467
 - eosinophil count in, 573–575
 - glucagon level in, 655–657
 - glucose level in, 658–662
 - glucose tolerance test for, 666–669

- human growth hormone levels in, 683–684
- LAP levels in, 796–797
- LDLC level in, 327–329
- luteinizing hormone secretion and, 815–816
- RBC count in, 384–388
- renin value and, 1037
- triglyceride levels and, 1109–1111
- urinalysis for, 1193
- WBC and differential in, 399–403
- zinc level in, 1235–1236
- Stress testing
 - exercise, 594–597
 - fetal, 1135
 - vasodilator and, 889
- Stress thallium, 888
- Stricture, 347–350
 - bronchoscopy for, 250–253
 - capsule endoscopy for, 274–276
 - cystoscopy for, 524–526
 - esophagogastroduodenoscopy for, 586–589
 - hepatobiliary scan for, 701–704
 - hysterosalpingography and, 728
 - percutaneous transhepatic cholangiography for, 315–318
 - proctosigmoidoscopy and, 986
 - retrograde ureteropyelography for, 1045–1048
 - retrograde urethrography for, 1183–1185
 - upper GI series for, 1172–1174
- Stroke, 295–298
- Strongyloides stercoralis* infection, 908–909
- Strongyloidiasis, 908–909
- Subacute bacterial endocarditis, 577–578
- Subacute endocarditis
 - erythrocyte sedimentation rate and, 577–578
 - RBC count in, 385–388
- Subacute sclerosing panencephalitis, 295–298
- Subacute thyroiditis, 1022–1023
- Subaortic stenosis
 - echocardiography for, 551–554
 - transesophageal echocardiography of, 554–557
- Subdural empyema, 837–839
- Subdural hematoma, 417–420
- Subluxation, 147–149
- Subphrenic abscess, 1148–1149
 - ultrasonography for, 1164–1166
- Succinylcholine hypersensitivity
 - acetylcholinesterase and, 1030
 - pseudocholinesterase level in, 1012
- Sucralfate, 1175
- Sulfate, 663
- Superficial venous thrombosis, ultra-sonography for, 1169
- Superior vena cava obstruction, 868
- Suppository, 606
- Suprapubic aspiration
 - for bacteria culture, 513
 - for urinalysis, 1198
 - for urine cytology, 536
- Suprapubic pain, 1139
- Surfactant, 792–795
- Surgery
 - D-dimer and, 539
 - mammography and, 863
 - plasminogen levels in, 946–947
 - prolactin level in, 991–993
 - skeletal muscle CK-MM and, 474–475
 - WBC and differential in, 400–403
- Surgical stress, 1098–1099
- Swan-Ganz catheter, 301–303
- Sweat chloride, 311–314
- Sweating
 - chloride values in, 310–314
 - loss of chloride from, 308
 - magnesium level and, 823–824
 - potassium levels and, 976–978
 - sodium levels and, 1065–1067, 1068–1071
 - vitamin D and, 1220–1221
- Symptomatic porphyria, 705–706
- Syndrome of inappropriate ADH secretion (SIADH), 129–130
 - osmotic concentration and, 900–902
- Syndrome X
 - CRP assay for, 471–472
 - glucose levels in, 659–662
 - HDLC and LDLC levels in, 326–329
 - total cholesterol level in, 331–333
 - triglyceride levels and, 1110–1111
- Synovial fluid analysis, 1077–1080
- Synovial tumor, arthrogram for, 144
- Synovitis
 - arthrogram of, 144–146
 - arthroscopy of, 147–149
 - MRI for, 848–850
- Synovium, trapped, arthroscopy for, 147–149
- Syphilis
 - cerebrospinal fluid analysis for, 295–298
 - erythrocyte sedimentation rate and, 577–578
 - rheumatoid factor and, 1049–1050
- Syphilis serology, 1081–1083
- Systemic lupus erythematosus (SLE)
 - antimitochondrial/antismooth muscle antibody in, 101–102
 - antinuclear antibody and, 106–108
 - beta₂-microglobulin levels in, 880–883

Systemic lupus erythematosus (SLE)

(continued)

- cold agglutinin titer levels in, 342–343
- complement protein levels in, 357–358, 359–360
- copper levels in, 462–463
- CRP assay for, 471–472
- cryoglobulin detection in, 485–486
- direct antiglobulin testing (DAT) for, 457–458
- erythrocyte sedimentation rate and, 577–578
- hyperlipoproteinemia and, 799–800
- immunoglobulin E level in, 737–738
- liver biopsy for, 194–197
- lung biopsy for, 198–201
- lupus anticoagulant antibody and, 811–813
- lymph node biopsy for, 202–205
- pericardial fluid analysis for, 932–934
- platelet antibody and, 948–949
- pleural fluid analysis and, 956–958
- rheumatoid factor and, 1049–1050
- skin biopsy for, 212–214
- synovial fluid analysis and, 1078–1080
- syphilis serology testing for, 1082–1083
- WBC and differential in, 400–403

Systemic mastocytosis, 639–642

Systemic neoplasm, 129–130

T

T₃ (triiodothyronine), 1112–1113
 free, 1112–1113
 total, 1114–1116

T₃ (triiodothyronine) toxicosis,
 1112–1113

T₄ (thyroxine), 1093, 1097
 free, 1099–1101
 total, 1101–1104

T₄-binding albumin, 1097T₄-binding globulin, 1097–1099T₄-binding globulin deficiency, 1097T₄-binding prealbumin, 1097

T cells (T lymphocytes), 398
 enumeration of, 291–293

T wave, 559–561

Tachycardia

- cardiac CK-MB and, 474–475
- electrocardiogram for, 559–561
- exercise stress test for, 595–597

Taenia saginata infection, 908–909*Taenia solium* infection, 908–909

Tamponade, 551–554

Tangier disease

- HDLc and LDLc levels in, 326–329

total cholesterol level in, 331–333

Tanner stages, 1084

Tapeworm disease, 908–909, 1218–1219

Target cell, 363, 392

Target heart rate, 594–597

Tarsal tunnel syndrome, 571–572

Tattoo, 833, 837, 841, 844, 848, 852, 856, 859

Tau protein, 32–34

Taurine, 40–41

Tay-Sachs disease

- amniotic fluid analysis for, 48–51

- hexosaminidase level in, 705–706

TBG (thyroxine-binding globulin),
 1097–1099

TBil (total bilirubin), 162–166

Teardrop cell, 363, 392

Tearing deficiency, 1055–1056

Technetium-99 agent, 889

Technetium-99 pertechnetate, 864–867

Technetium-99 stannous pyrophosphate
 (PYP) scanning, 885

Temperature, environmental, 952

Temporal arteritis, ESR and, 577–578

Temporal lobe seizure, 563–564

Tendon xanthoma

- LDLc level in, 327–329

Teratogenesis, 1228

Testicle abnormality, 1161–1163

Testicular atrophy, 1058–1059

Testicular biopsy, 109–110

Testicular cancer, 109–110

Testicular carcinoma, 614–617

Testicular dysfunction, 630–631

Testicular efferent duct, blocked,
 109–110

Testicular failure, 1058–1059

Testicular infection, 1161–1163

Testicular inflammation. *See* Orchitis

Testicular torsion

- infertility and, 109–110

- ultrasonography for, 1162–1163

Testicular tumor, 1085–1086

Testis, 542

Testosterone, 542, 1084–1086

Testosterone-producing tumor,
 1098–1099

Tetanus

- aldolase levels in, 18–19

- electromyography for, 566–567

- skeletal muscle CK-MM and, 474–475

Tg (thyroglobulin), 1087–1088

TGs (triglycerides), 605, 1108–1111

Thalassemia

- copper levels in, 462–463

- ferritin level in, 609–610

- hemoglobin electrophoresis for,
 689–691

- iron level in, 762–764
 - osmotic fragility and, 902–903
 - RBC indices in, 390–391
 - RBC morphology in, 393–396
 - sickle cell screen for, 1060–1061
 - total iron-binding capacity and, 765–766
- Thalassemia major
 - amino acid levels in, urine test for, 40
 - hemosiderin levels in, 692–693
 - total cholesterol level in, 331–333
- Thallium scan, 888
- Theca lutein cyst, 989–990
- Theophylline administration, 976–978
- Thermal stress, 20–22
- Thiamine, 1226
- Thoracentesis, 16–18
- Thoracentesis fluid analysis, 954–958
- Thoracic aortic disease, 844–846
- Thoracic aortic dissection, 554–557
- Thoracic outlet syndrome, 571–572
- Thorax. *See* Chest *entries*
- Threatened abortion
 - amniotic fluid analysis in, 46
 - chorionic villus biopsy in, 185
 - fetal fibronectin in, 611
 - human chorionic gonadotropin level in, 715
 - progesterone testing in, 989–990
 - ultrasound biophysical profile in, 1134–1139
- Threonine, 40–41
- Throat
 - culture from, 509–511
 - MRI of, 836
- Thromboangitis obliterans, plethysmography for, 950–954
- Thrombocyte, 378–382
- Thrombocythemia, 378, 379–382
- Thrombocytchemic purpura, 663
- Thrombocytopenia, 378
 - bleeding time in, 220
 - LAP levels in, 796–797
 - lupus anticoagulant antibody and, 811
 - platelet antibody and, 948–949
 - platelet count in, 379–382
- Thrombocytopenic purpura
 - bone marrow biopsy for, 174–177
 - ultrasonography for, 1164–1166
 - WBC and differential in, 400–403
- Thrombocytosis, 4, 378
- Thromboembolism, lupus anticoagulant antibody and, 811
- Thrombolytic therapy, 894–895
- Thrombopoiesis, 380
- Thrombopoietin deficiency, 380–382
- Thrombosis
 - antithrombin III and, 135
 - cardiolipin antibody in, 114
 - D-dimer and, 539
 - Doppler flow study for, 950
 - kidney biopsy in, 191
 - lupus anticoagulant antibody and, 811
 - MRA for, 829
 - MRI for, 833
 - plethysmography for, 951
 - renogram for, 539
 - TEE in, 555
 - ultrasonography for, 1169
- Thrombotic thrombocytopenic purpura, platelet count in, 380–382
- Thrombus
 - echocardiography for, 551–554
 - transesophageal echocardiography of, 554–557
- Thymoma, 1
- Thyrocalcitonin, 256–259
- Thyroglobulin, 1087–1088
- Thyroid cancer, 112–113
 - calcitonin stimulation test for, 257–259
 - cortisol levels in, 465–467
 - thyroglobulin values in, 1087–1088
 - thyroid biopsy for, 215–217
 - ultrasonography for, 1167–1168
- Thyroid disease
 - antimitochondrial/antismooth muscle antibody in, 101–102
 - copper levels in, 462–463
 - thyroid-binding inhibitory immunoglobulin and, 1089
- Thyroid dysfunction
 - albumin/globulin ratio, 16–18
 - antidiuretic hormone and, 129–130
 - Thyroid failure, 1114–1116
- Thyroid gland. *See also* Hyperthyroidism; Hypothyroidism
 - biopsy of, 215–217
 - carcinoma of, 112–113. *See also* Thyroid cancer
 - cyst of
 - biopsy for, 215–217
 - ultrasonography for, 1167–1168
 - disease/dysfunction of. *See* Thyroid disease; Thyroid dysfunction
 - radioactive iodine uptake by, 1021–1023
 - ultrasonography of, 1166–1168
- Thyroid hormone, 1087–1088. *See also* Hyperthyroidism; Hypothyroidism; Thyroxine; Triiodothyronine
- Thyroid scan, 1089–1092
- Thyroid storm, 400–403
- Thyroid surgery, 1087–1088

- Thyroid toxicity, 566–567
- Thyroid-binding immunoglobulin, 1095
- Thyroid-binding inhibitory immunoglobulin, 1089
- Thyroiditis
- calcitonin stimulation test for, 257–259
 - complement protein levels in, 357–358
 - radioactive iodine uptake and, 1022–1023
 - thyroglobulin values in, 1087–1088
 - thyroid scan for, 1090–1092
 - thyroid-stimulating hormone and, 1093–1095
- Thyroid-stimulating hormone, 1093–1095
- Thyroid-stimulating immunoglobulin (TSD), 1096–1097
- Thyrotoxicosis
- calcium values in, 261–263
 - fecal fat and, 606–608
 - glucose levels in, 659–662
 - potassium levels and, 976–978
 - radioactive iodine uptake and, 1022–1023
 - thyroglobulin values in, 1087–1088
 - thyroid scan for, 1090–1092
 - total thyroxine level and, 1102–1104
 - total triiodothyronine levels and, 1114–1116
 - urinary calcium levels in, 269–271
 - vitamin D and, 1220–1222
 - WBC and differential in, 400–403
- Thyroxine, 1093, 1097
- free, 1099–1101
 - total, 1101–1104
- Thyroxine-binding albumin, 1097
- Thyroxine-binding globulin (TBG), 1097–1099
- Thyroxine-binding globulin deficiency, 1097
- Thyroxine-binding prealbumin, 1097
- Tidal volume, 1013
- Timed specimen
- for D-xylose tolerance test, 547–550
 - for magnesium measurement, 826
 - for microalbumin testing, 878
 - oxalate levels and, 912
 - phosphorus levels and, 944–945
 - porphyrin levels and, 960–962
 - potassium levels and, 981
- Tine test, 1118
- Tinnitus, 154–156
- Tissue, 1027–1029
- Tissue necrosis
- ceruloplasmin levels in, 299–300
 - fibrinogen level in, 620–622
 - prealbumin and, 983–984
 - WBC and differential in, 400–403
- Tissue poisoning, 400–403
- Tissue sample, 514–516
- Tissue specimen, 1263
- Tissue trauma
- magnesium level and, 822–824
 - potassium levels and, 975–978
- Tobacco. *See* Smoking
- Tobramycin, 92–96
- Tocopherol, 1222
- Toddler communication, 1265–1266
- Togavirus, 517–519
- Tomography. *See* Computed tomography (CT); Positron emission tomography (PET)
- Tonsillitis, 680–681
- TORCH panel, 537, 1104
- Torsion, 1162–1163
- Total bilirubin (TBil), 162–166
- Total cholesterol, 329–333
- Total iron-binding capacity, 764–766
- Total lung capacity, 1013
- Total parenteral nutrition
- ammonia levels with, 44–45
 - hepatobiliary scan and, 702
- Total thyroxine, 1101–1104
- Total triiodothyronine, 1114–1116
- Tourette's syndrome, 131–134
- Tourniquet constriction
- erythrocyte sedimentation rate and, 577–578
 - fibrinogen level and, 621
 - lactic acid levels and, 777
 - lupus anticoagulant antibody and, 811
 - protein C levels and, 999, 1002
- Toxemia
- aldosterone levels in, 20–22
 - erythrocyte sedimentation rate and, 577–578
 - urine urea nitrogen level in, 1181–1182
- Toxic chemicals, 400–403
- WBC and differential in, 400–403
- Toxic hepatitis, 24–26
- Toxoplasma* antibody, 1104
- Toxoplasma gondii*, 1104
- Toxoplasmosis, 1104
- Tracheal suctioning, 532–533
- Tracheostomy tube, chest x-ray and, 301–303
- Trachoma, 1062–1064
- Transbronchial lung biopsy, 197
- Transcatheter bronchial brushing, 198
- Transcutaneous bilirubin monitor, 163
- Transducer, 554

- Transesophageal echocardiography (TEE), 554–557
- Transferrin, 764, 1106–1108
- Transfusion
- bilirubin levels in, 164–166
 - bone marrow biopsy after, 175–177
 - calcium and, 261–263
 - cytomegalovirus and, 537
 - direct antiglobulin testing (DAT) for, 457–458
 - erythropoietin level and, 581
 - fibrinogen level and, 621
 - haptoglobin level in, 686–687
 - hemoglobin in, 374–378
 - hemoglobin levels after, 690
 - hemosiderin levels in, 692–693
 - hepatitis B antigen/antibody and, 695
 - human T-lymphotropic virus antibodies and, 722–724
 - iron level and, 761, 762–764
 - platelet antibody and, 948–949
 - platelet count in, 380–382
 - potassium levels and, 975–978
 - rheumatoid factor and, 1049–1050
 - sickle cell screen and, 1060
 - syphilis serology testing for, 1082–1083
 - WBC and differential in, 400–403
- Transfusion reaction
- acute immune-mediated, 1269–1270
 - acute non-immune-mediated, 1270–1271
 - delayed immune-mediated, 1272
 - delayed non-immune-mediated, 1272
- Transitional cell, 1195
- Transmission, of microorganism, 1277–1279
- Transmission-based precautions, 1283–1285
- Transthyretin, 982
- Transudate, 931, 935, 954
- Transverse position (of fetus), 1136–1139
- Trauma
- abdominal angiography of, 58–61
 - abdominal CT of, 404–407
 - albumin/globulin ratio, 16–18
 - amylase levels in, 52–53
 - brain CT of, 417–420
 - carotid angiography of, 67–69
 - cerebrospinal fluid analysis for, 295–298
 - chloride values in, 307–310
 - complement protein levels in, 359–360
 - copper levels in, 462–463
 - coronary angiography of, 70–73
 - electromyography in, 566–567
 - electroneurography for, 571–572
 - glucagon level in, 655–657
 - glucose levels in, 659–662
 - gonioscopy for, 676–677
 - hearing loss audiometry for, 154–156
 - ionized calcium values in, 265–267
 - liver and spleen scan for, 801–803
 - mammography for, 862–864
 - otoscopy for, 906–907
 - peritoneal fluid analysis for, 936–938
 - platelet count in, 380–382
 - plethysmography for, 950–954
 - potassium levels and, 975–978
 - renal angiography in, 79–82
 - renogram for, 1040–1042
 - skeletal muscle CK-MM and, 474–475
 - splenic CT of, 450–453
 - synovial fluid analysis and, 1078–1080
 - to RBC, hemosiderin and, 692–693
 - ultrasonography for, 1148–1149, 1164–1166
 - voiding cystourethrography for, 527–529
- Traumatic nerve transection, 570
- Trematode disease, 908–909
- Treponema*, 816
- Treponema pallidum*, 494–497, 1081
- Trichinosis, 18–19
- Trichomonas vaginalis*, 915, 917
- Trichophyton*, 515–516
- Trichuriasis, 908–909
- Tricyclic antidepressants, 133–134, 544–547
- Tricyclic glycopeptide, 92–96
- Trigeminal neuralgia, 119
- Triglycerides (TGs), 605, 1108–1111
- Triiodothyronine, 1112–1113
- free, 1112–1113
 - total, 1114–1116
- Triiodothyronine toxicosis, 1112–1113
- Triple X syndrome, 334
- Triple-marker testing, 613, 614, 715
- Trophoblastic tumor, 1085–1086
- Tropical sprue, 261–263
- copper levels in, 462–463
 - D-xylose tolerance test for, 547–550
 - fecal fat and, 606–608
 - glucose tolerance test for, 666–669
 - 5-hydroxyindoleacetic acid level in, 724–726
 - intestinal biopsy for, 188–190
 - urinary calcium levels in, 269–271
- Troponins I and T, cardiac, 1116–1118
- Trypanosomiasis
- cold agglutinin titer levels in, 342–343
 - syphilis serology testing for, 1081–1083

- Trypsin, 602–603
 Tryptophan, 40–41
 Tsanck smear, 212–214
 Tubercular meningitis, 295–298
 Tuberculin skin test, 1118–1122
 Tuberculosis
 alkaline phosphatase levels in, 24–26
 blood gas analysis in, 227–232
 bronchoscopy for, 250–253
 calcium values in, 260–263
 carbon dioxide levels in, 278–279
 chest x-ray for, 302–303
 copper levels in, 462–463
 culture and smear, 487
 eosinophil count in, 573–575
 erythrocyte sedimentation rate and, 577–578
 lung biopsy for, 198–201
 lung perfusion scan for, 805–807
 lung ventilation scan for, 808–810
 mediastinoscopy for, 868–871
 Mycobacterium kansasii, 488
 platelet count in, 380–382
 pleural fluid analysis and, 956–958
 pseudocholinesterase level in, 1012
 pulmonary angiography of, 74–77
 rheumatoid factor and, 1049–1050
 syphilis serology testing for, 1082–1083
 tuberculin skin test for, 1118–1122
 vitamin A and, 1228
 zinc level in, 1235–1236
 Tuberculosis meningitis, 129–130
 Tuberculous arthritis, 1078–1080
 Tuberculous empyema, 956–958
 Tuberculous pericarditis, 932
 Tuberos xanthoma, 327–329
 Tubular carcinoma, 1143–1147
 Tubular necrosis
 MRI for, 833–835
 renogram for, 1040–1042
 Tubular phase, 1039–1042
 Tumor(s). *See also particular types and site-specific entries*
 abdominal angiography of, 58–61
 abdominal CT of, 404–407
 albumin/globulin ratio and, 16–18
 barium enema for, 157–159
 barium swallow for, 160–162
 bilirubin levels in, 164–166
 bladder biopsy for, 166–169
 blood gas analysis in, 227–232
 bone marrow biopsy for, 174–177
 bone scan for, 245–248
 brain CT of, 417–420
 breast biopsy for, 179–181
 bronchoscopy for, 250–253
 BUN level in, 1178–1180
 calcitonin stimulation test for, 257–259
 cancer antigen levels in, 284–285
 capsule endoscopy for, 274–276
 carbon dioxide levels in, 277–279
 carotid angiography of, 67–69
 cerebrospinal fluid analysis for, 295–298
 chest x-ray for, 302–303
 colonoscopy for, 347–350
 colonoscopy for recurrence of, 426–429
 copper levels in, 462–463
 coronary angiography of, 70–73
 C-peptide levels in, 468–469
 CT angiography of, 408–412
 cystoscopy for, 524–526
 DHEAS and, 542–543
 echocardiography for, 551–554
 EEG determining, 563–564
 ERCP for, 321–324
 erythropoietin level in, 581–582
 esophagogastroduodenoscopy for, 586–589
 estradiol level in, 589–590
 evoked brain potentials in, 591–594
 fecal analysis for, 603–604
 fluorescein angiography for, 623–625
 folate level in, 627–628
 gallium scan for, 636–638
 gastrointestinal blood loss scan, 651–654
 glucose tolerance test for, 666–669
 gonioscopy for, 676–677
 gynecologic laparoscopy for, 786–788
 haptoglobin level in, 686–687
 hearing loss audiometry for, 154–156
 hepatobiliary scan for, 701–704
 human chorionic gonadotropin level in, 715–717
 human growth hormone levels in, 683–684
 5-hydroxyindoleacetic acid level in, 724–726
 hysterosalpingography for, 728–730
 intravenous pyelography for, 756–758
 kidney CT for, 442–445
 liver and spleen scan for, 801–803
 liver biopsy for, 194–197
 liver/biliary tract CT of, 412–416
 lung ventilation scan for, 808–810
 lymphangiography for, 819–821
 mammography for, 862–864
 metanephrine levels and, 872–873
 MRA for, 829–831
 MRI for, 833–835, 837–839, 848–850, 855–857, 858–861
 myocardial infarction scan and, 886

- pancreatic CT of, 429–433
 pelvic CT of, 433–437
 percutaneous transhepatic cholangiography for, 315–318
 PET scan for, 963–966, 971–973
 phosphorus levels in, 940–942
 proctosigmoidoscopy for, 986–988
 progesterone testing for, 989–990
 prolactin level in, 991–993
 prostatic biopsy for, 208–211
 protein level in, 996–998
 pulmonary angiography of, 74–77
 pulmonary function study for, 1016–1017
 radiofrequency ablation of, 1024–1027
 radiography for, 1028–1029
 renal angiography of, 79–82
 renogram for, 1040–1042
 retrograde ureteropyelography for, 1045–1048
 retrograde urethrography for, 1183–1185
 skeletal muscle CK-MM and, 474–475
 spinal CT for, 446–449
 splenic CT of, 450–453
 sputum cytology for, 530–534
 TBG level in, 1098–1099
 testosterone and, 1085–1086
 thoracic CT for, 454–456
 thyroid biopsy for, 215–217
 thyroid scan for, 1090–1092
 thyroid-stimulating hormone and, 1093–1095
 TNM classification of, 209
 transesophageal echocardiography of, 554–557
 ultrasonography for, 1140, 1143, 1150, 1153, 1155, 1164
 upper GI series for, 1172–1174
 urinary calcium levels in, 268–271
 vertebroplasty for, 1211–1214
 visual field test for, 1215–1217
 voiding cystourethrography for, 527–529
- Tumor therapy, 1156–1158
 Tunica albuginea cyst, 1162–1163
 Tuning fork test, 1122–1125
 Turner's syndrome
 aldolase levels in, 21–22
 estradiol level in, 589–590
 follicle-stimulating hormone level in, 629–631
- Tuttle test, 582, 585
 Tympanic membrane, 905–907
 Type 1 diabetes (insulin-dependent). *See also* Diabetes mellitus
 C-peptide levels in, 468
 insulin levels in, 745
 intrinsic factor antibody and, 759
 Type 2 diabetes (non-insulin-dependent). *See also* Diabetes mellitus
 C-peptide levels in, 468
 insulin levels in, 745
- Typhoid fever
 bacterial culture for, 498–501
 copper levels in, 462–463
- Tyrosine crystal, 1196
 Tyrosinemia
 amino acid levels in, urine test for, 40
 D-aminolevulinic acid levels in, 41–43
- Tyrosinemia type 1, 40–41
 Tyrosinosis, 40
 Tzanck smear, 212–214
- ## U
- Ulcer
 barium swallow for, 160–162
 capsule endoscopy for, 274–276
 colonoscopy for, 347
 fecal analysis for, 603–604
 fecal fat and, 606–608
 gastrointestinal blood loss scan, 651–654
 peptic, 16–18
 slit-lamp biomicroscopy for, 1062–1064
 upper GI series for, 1172–1174
- Ulcerative colitis, 996–998
 alkaline phosphatase levels in, 25–26
 antineutrophilic cytoplasmic antibodies in, 103–104
 barium enema for, 157–159
 bone marrow biopsy for, 174–177
 fecal analysis for, 603–604
 folate level in, 627–628
 haptoglobin level in, 686–687
 platelet count in, 380–382
 proctosigmoidoscopy for, 986–988
 WBC and differential in, 400–403
- Ullrich-Turner syndrome, 334
- Ultrasonography
 arterial Doppler
 carotid studies with, 1126–1128
 extremity studies with, 1128–1131
 A-scan, 1131–1133
 biophysical profile, obstetric, 1134–1139
 cystoscopy and, 523
 obstetric, 1134–1139
 of bladder, 1139–1141
 of breast, 1142–1144
 of kidney, 1144–1147
 of liver and biliary system, 1147–1149

- Ultrasonography (*continued*)
 - of lymph nodes and retroperitoneum, 1150–1152
 - of pancreas, 1152–1154
 - of pelvis (gynecologic/nonobstetric), 1155–1158
 - of prostate, 1158–1160
 - of scrotum, 1161–1163
 - of spleen, 1163–1166
 - of thyroid and parathyroid glands, 1166–1168
 - stereotactic biopsy and, 1074
 - venous Doppler, extremity studies with, 1168–1170
- Ultrasound biophysical profile, 1134–1139
- Ultrasound densitometry, 242–245
- Umbilical cord sampling, 1256
- Unconjugated/indirect bilirubin, 162–166
- Underventilated alveoli, 30–32
- Upper duodenum
 - capsule endoscopy of, 273–276
 - esophagogastroduodenoscopy of, 586–589
- Upper gastrointestinal series, 1171–1174
- Upper gastrointestinal tract, 586
- Upper respiratory tract infection, 518–519
- Urate, 1185–1188
- Urea, 1004
- Urea breath test, 1175–1177
- Urea nitrogen
 - in blood specimen, 1177–1180
 - in urine specimen, 1180–1182
- Uremia, 84–86
 - abdominal laparoscopy and, 783
 - glucose levels and, 660
 - platelet count in, 380–382
 - potassium levels and, 975–978
 - pseudocholinesterase level in, 1012
 - testosterone and, 1085–1086
 - vitamin B₆ and, 1228
 - WBC and differential in, 400–403
- Ureter, 755–758
- Ureteral calculi, 756–758
- Ureteral obstruction
 - kidney CT for, 442–445
 - ultrasonography for, 1145–1147
- Ureteral orifice, 523–526
- Ureteral stent, 524–526
- Ureteral stricture
 - cystoscopy for, 524–526
 - voiding cystourethrography for, 527–529
- Ureterocele
 - ultrasonography for, 1140–1141
 - voiding cystourethrography for, 527–529
- Ureteropelvic junction obstruction, 1045–1048
- Urethra
 - cystoscopy of, 523–526
 - voiding cystourethrography of, 526–529
- Urethral calculi, 1183–1185
- Urethral diverticula
 - retrograde urethrography for, 1183–1185
 - voiding cystourethrography for, 527–529
- Urethral fistula, 1183–1185
- Urethral obstruction, cystometry and, 521
- Urethral stricture, 524–526
- Urethritis
 - Chlamydia* antibody testing for, 304–306
 - cystoscopy and, 524
- Urethrography, retrograde, 1183–1185
- Urethroscopy, 523
- Uric acid, 242–245
 - in blood specimen, 1185–1188
 - in blood versus urine, 1189
 - in urine specimen, 1188–1191, 1196
- Urinalysis, 1192–1199
- Urinary bladder. *See* Bladder
- Urinary calcium, 267–271
- Urinary catheterization
 - for bacteria culture, 513
 - for urinalysis, 1198
 - for urine cytology, 536
- Urinary elimination dysfunction
 - cystometry and, 520–523
 - cystoscopy and, 523–526
- Urinary 17–ketosteroid, 542
- Urinary retention
 - cystometry for, 520–523
 - PSA levels and, 994–995
- Urinary tract
 - urine cytology for
 - cancer, 535
 - inflammatory disease, 535
- Urinary tract abnormality
 - cystoscopy for, 524–526
 - intravenous pyelography for, 756–758
 - retrograde ureteropyelography for, 1045–1048
- Urinary tract infection (UTI)
 - bacterial culture for, 512–514
 - cystometry for, 520–523
 - microalbumin and, 877–879
 - protein levels in, 1004–1006
 - renogram for, 1040–1042
 - urine cytology for, 534–536
 - voiding cystourethrography and, 526–527
- Urinary tract malignancy, 1004–1006

- Urinary tract obstruction
 BUN level in, 1178–1180
 ultrasonography for, 1140–1141
 urine creatinine clearance test and, 482–484
- Urine
 albumin levels in, 876–879
 amino acid screening, 39–41
 bacterial culture for, 511–514
 beta₂-microglobulin levels in, 881–883
 bladder cancer markers in, 218–219
 casts in, 1195–1196
 catecholamine levels in, 286–290
 cellular elements of, 1195
 color of, 1193
 creatinine levels in, 480–484
 crystals in, 1196
 cytology of, 534–536
 dipstick analysis of, 1192, 1196
 immunofixation electrophoresis of, 731–733
 ketones, measuring levels in, 769
 magnesium level in, 822–824
 microscopic analysis of, 1192
 osmotic concentration in, 899–902
 oxalate levels in, 910–912
 protein level in, 1003–1006
 urea nitrogen in, 1180–1182
 uric acid level in, 1188–1191
 urinalysis of, 1192–1199
 vitamin D and, 1220–1221
- Urine phosphate, 942
- Urine specimen. *See also* Clean-catch specimen
 collection procedure for, 1261–1263
 for drug abuse, 545
 patient preparation for, 1261
- Urine urate, 1188–1191
- Urobilinogen, 1194
- Urodynamic testing of bladder function, 520–523
- Uropathy, obstructive, 1040–1042
- Urothelial carcinoma, 284–285
- Urticaria, 640–642
- Urticarial/allergic reaction, 1270
- Uterine fibroid
 hysterosalpingography for, 728–730
 laparoscopy for, 786–788
 MRI for, 855–857
 pelvic CT of, 433–437
 ultrasonography for, 1156–1158
- Uterine fibroid embolization, 1199–1202
- Uterine fistula, 728–730
- Uterine hemorrhage, 1199
- Uterine mass/foreign body, 728–730
- Uterine tumor, 1156–1158
- Uterography, 727
- Uterosalpingography, 727
- Uterus
 gynecologic laparoscopy of, 785–788
 hysterosalpingography of, 727
- UTI. *See* Urinary tract infection (UTI)
- Uveitis, 676–677
- V**
- Vaccinia
 syphilis serology testing for, 1082–1083
- Vacuum-assisted needle biopsy, 1074
- Vacuuumized needle and holder system, venipuncture using, 1258–1259
- Vagal hyperfunction, 640–642
- Vaginal adenosis, 917
- Vaginitis, 1195
- Vagotomy
 gastrin stimulation test for, 645–647
 glucose tolerance test for, 666–669
- Valine, 40–41
- Valproic acid, 117–121
- Valsalva technique, 1169
- Valve competency, 951–954
- Valvular calcification, 886
- Valvular disease, 70–73
- Vancomycin, 92–96
- Vancomycin-resistant enterococci (VRE), 512–514
- Vanillylmandelic acid (VMA), 712
 urine, 1203–1205
- Variable upper airway obstruction, 1014
- Varicella, 212–214
- Varicella antibody, 1205–1207
- Varicella-zoster antibody, 1205–1207
- Varicella-zoster virus, 517–519
- Varicocele
 infertility and, 109–110
 semen analysis for, 1058–1059
 ultrasonography for, 1162–1163
- Varicose vein, 1169–1170
- Vascular abnormality
 colonoscopy for, 347–350
 MRA for, 829–831
 proctosigmoidoscopy for, 986–988
- Vascular blockage, 67–69
- Vascular calcification, 862–864
- Vascular disease
 MRI for, 855–857
 renogram for, 1040–1042
- Vascular disorder
 chest x-ray for, 302–303
 CT angiography of, 408–412
 fluorescein angiography for, 623–625
 hearing loss audiometry for, 154–156
- Vascular injury
 fibrinogen level and, 621

- Vascular injury (*continued*)
- lupus anticoagulant antibody and, 811
 - protein C levels and, 999, 1002
- Vascular lesion, 441–445
- Vascular malformation, 446–449
- Vascular phase, 1039–1042
- Vascular system, 966–970
- Vascular trauma, 951–954
- Vasculitic disease, 103–104
- Vasculitis
- antineutrophilic cytoplasmic antibodies in, 103–104
 - beta₂-microglobulin levels in, 881–883
 - complement protein levels in, 359–360
 - WBC and differential in, 400–403
- Vasectomy, 1057–1059
- Vasectomy reversal
- infertility and, 109–110
 - semen analysis for, 1057–1059
- Vasoconstriction, 1019
- Vasoconstrictor, angiotensin II as, 1035–1039
- Vasodilator-mediated myocardial perfusion scan, 889
- Vector borne transmission of pathogen, 1278
- Vegetable deficiency
- potassium levels and, 976–978
 - vitamin B₁₂ and, 1218–1219
- Vegetarian diet, 482–484
- Vein(s), lower extremity
- Doppler study of, 1168–1170
 - venogram of, 1207–1211
- Vena cava obstruction, 833–835
- Venereal Disease Research Laboratory (VDRL) testing, 1081
- Venipuncture
- aPTT and, 927
 - fibrin degradation product and, 618–619
 - fibrinogen level and, 621
 - indwelling device, 1260
 - locks and catheters in, 1256–1257
 - needle placement in, 1259
 - of arm, 1255
 - of capillary
 - collection procedure for, 1257–1258
 - finger or heel, 1253–1254
 - of hand and wrist, 1255
 - of radial artery, 1256
 - prolactin and, 992
 - prothrombin time and, 1009–1011
 - radial arterial puncture, 1256
 - collection procedure for, 1259–1260
 - umbilical cord sampling, 1256
 - using syringe, vacuumized needle and holder system, 1258–1259
- Venogram, 1207
- Venography, lower extremity study, 1207–1211
- Venous blood gas, 221–232
- Venous Doppler study, 1168–1169
- Venous duplex, 1168
- Venous duplex imaging, 1168–1171
- Venous insufficiency, 1169–1170
- Venous malformation, venography of, 1207–1211
- Venous occlusion
- fluorescein angiography for, 623–625
 - ultrasonography for, 1169
 - visual field test for, 1215–1217
- Venous plethysmography, 950–954
- Venous sonogram, 1168–1171
- Venous thrombosis
- antithrombin III levels in, 135
 - cardiolipin antibody in, 114
 - D-dimer and, 539
 - Doppler flow study for, 950
 - kidney biopsy in, 191
 - MRI for, 833
 - renogram for, 1040
 - ultrasonography for, 1169
- Venous trauma, 1170
- Venous ultrasound, 1168–1170
- Ventilation-perfusion scan, 804–807
- Ventral wall defect, 48–51
- Ventricle, enlarged left, 239–241
- Ventricular aneurysm, 551–554
- Ventricular displacement, 417–420
- Ventricular dysfunction, 254–255
- Ventricular hypertrophy
- echocardiography for, 551–554
 - electrocardiogram for, 559–561
 - exercise stress test and, 595–597
 - transesophageal echocardiography of, 555–557
- Ventricular mural thrombus
- echocardiography for, 551–554
 - transesophageal echocardiography of, 554–557
- Ventricular septal defect
- lung perfusion scan and, 805
 - myocardial perfusion heart scan for, 890–893
- Ventricular thrombus, echocardiography for, 551–554
- Ventriculitis, 837–839
- Vertebroplasty, 1211–1214
- Very-low-density lipoprotein (VLDL), 799–800
- Very-low-density lipoprotein cholesterol (VLDLC), 326
- Vesicoureteral reflux, 527–529

- Vessel occlusion
MRA for, 829–831
ultrasonography for, 1129–1131
- Vessel stenosis, 829–831
- Viagra (Sildenafil), 890
- Viral culture, 517–519
- Viral hepatitis
alkaline phosphatase levels in, 24–26
amino acid levels in, urine test for, 40
antimitochondrial/antismooth muscle
antibody in, 101–102
complement protein levels in,
357–358
fecal fat and, 606–608
G6PD levels in, 663
lactate dehydrogenase levels in,
775–776
syphilis serology testing for,
1082–1083
- Viral infection
beta₂-microglobulin levels in,
881–883
bone marrow biopsy for, 174–177
complement protein levels in,
357–358
fecal analysis for, 603–604
platelet count in, 380–382
rheumatoid factor and, 1049–1050
skin biopsy for, 212–214
sputum cytology for, 530–534
WBC and differential in, 400–403
- Viral load, 291
- Viral pericarditis, 932–934
- Virilization, 542–543
- Virilizing ovarian tumor, 1085–1086
- Virtual colonoscopy, 425
- Virus, 400–403
- Visceral injury, 801–803
- Visceral larva migrans, 28
- Viscus, ruptured, 771–772
- Visual acuity, 1032–1035
- Visual acuity scale, 1033
- Visual cortex defect, 591–594
- Visual evoked response (VER), 590
- Visual field test, 1215–1217
- Visual loss
MRI for, 858–861
nerve fiber analysis for, 896–898
visual field test for, 1215–1217
- Vital capacity, 1013
- Vitamin(s)
aPTT and, 927
BUN level and, 1178
oxalate levels and, 911
parathyroid hormone and, 921–922
phosphorus levels and, 943
- Vitamin A, 1226–1230
- Vitamin B₁, 1226–1230
- Vitamin B₆, 1226–1230
- Vitamin B₆ deficiency, 910–912
- Vitamin B₁₂, 1217–1219
- Vitamin B₁₂ deficiency
bone marrow biopsy for, 174–177
folate level in, 626–628
glucose levels and, 659–662
homocysteine level and, 709–711
iron level and, 762–764
RBC morphology in, 393–396
WBC and differential in, 399–403
- Vitamin C, 1226–1230
deficiency and alkaline phosphatase
levels, 25–26
fecal analysis and, 603
sources of, 1230
- Vitamin D, 1220
calcium values and, 260, 261
ionized, 265–267
urinary, 269–271
phosphorus levels and, 940–942,
943–945
- Vitamin deficiency, 1228
amino acid levels in, urine test for, 40
RBC indices in, 389–391
toxicity and, 1223
- Vitamin E, 1222–1224
- Vitamin K
disease affecting, 1225–1226
forms of, 1224
osteocalcin and, 903
- Vitamin K deficiency
antithrombin III levels in, 135–136
aPTT in, 927–929
prothrombin time and, 1008–1011
- Vitamin K-dependent protein, 999, 1001,
1007
- Vitreous traction syndrome, 1216–1217
- VLDL (very-low-density lipoprotein),
799–800
- VLDLC (very-low-density lipoprotein
cholesterol), 326
- VMA (vanillylmandelic acid), 712
urine, 1203–1205
- Voiding, bladder pressure during, 521
- Voiding cystography, 526–529
- Voiding cystourethrography, 526–529
- Voiding disorder, 520–523
- Voluntary ventilation, 1012–1017
- Volvulus, 157–159
colonoscopy and, 347
proctosigmoidoscopy and, 985
- Vomiting, 84–86
acetaminophen intoxication and, 55
antiarrhythmic toxicity and, 89
anticonvulsant toxicity and, 120
antipsychotic toxicity and, 133
blood gas analysis in, 227–232
carbon dioxide levels in, 277–279
chloride values from, 308–310

- Vomiting (*continued*)
- digoxin toxicity and, 89
 - D-xylose level and, 547–550
 - EM and, 583
 - GER and, 648
 - GER scan and, 648
 - glucose tolerance test and, 667–669
 - illness with, ketones and, 767–770
 - magnesium and, 823
 - MRI for, 858–861
 - phosphorus levels in, 940–942
 - potassium levels and, 976–978, 980–982
 - radioactive iodine uptake and, 1022
 - salicylate toxicity and, 55
 - sodium levels and, 1065–1067
 - thyroid scan and, 1090
 - urine porphyrins and, 960
- von Gierke disease
- glucose levels in, 659–662
 - glucose tolerance test for, 666–669
 - total cholesterol level in, 330–333
- von Willebrand's disease
- aPTT in, 927–929
 - bleeding time in, 220
- V/Q scan, 804–807, 807–810
- VRE (vancomycin-resistant enterococci), 512–514
- W**
- Waldenstrom's macroglobulinemia
- albumin/globulin ratio, 16–18
 - cryoglobulin detection in, 485–486
 - erythrocyte sedimentation rate and, 577–578
 - immunofixation electrophoresis for, 731
 - immunoglobulin E level in, 737–738
 - protein level in, 996–998
 - rheumatoid factor and, 1049–1050
 - total cholesterol level in, 331–333
 - WBC and differential in, 400–403
- Wall motion study, 237–241
- Warfarin, 539
- Warkam syndrome, 334
- Wart, 212–214
- Wash-in phase, 808
- Wash-out phase, 808
- Wasting disease
- aldolase levels in, 18–19
 - BUN level in, 1178–1180
 - creatinine clearance and, 482
- Water intoxication
- chloride values in, 308–310
 - osmotic concentration and, 900–902
- Waxy cast, 1196
- WBC. *See* White blood cell *entries*
- Weber test, 1123–1124
- Wegener's granulomatosis, 102–104
- Wegener's syndrome, 102–104
- Weight loss
- apolipoprotein A and B in, 141–143
 - upper GI series for, 1172–1174
- Welding industry, lead and, 789–791
- Werner's syndrome
- apolipoprotein B and, 141–143
 - total cholesterol level in, 331–333
 - triglyceride levels and, 1110–1111
- Whipple's disease
- alkaline phosphatase levels in, 25–26
 - D-xylose tolerance test for, 547–550
 - fecal fat and, 606–608
 - folate level in, 627–628
 - glucose tolerance test for, 666–669
 - 5-hydroxyindoleacetic acid level in, 725–726
- White blood cell count/differential, 396–403
- complete blood count and, 362, 365–367
 - glucose levels and, 660
- White blood cell scan, 1231–1233
- Whole blood
- bleeding time, 220
 - blood gas analysis, 221–232
- Whole body bone scan, 245–248
- Wilson's disease
- amino acid levels in, urine test for, 40
 - blood gas analysis in, 227–232
 - ceruloplasmin levels in, 299–300
 - copper levels in, 462–463
 - liver biopsy for, 195–197
 - uric acid level in, 1187–1188, 1189–1191
 - urinary calcium levels in, 268–271
 - zinc level in, 1234–1236
- Wiskott-Aldrich syndrome
- immunoglobulin E level in, 734–735, 737–738
 - platelet count in, 380–382
- Wolff-Parkinson-White syndrome, 595–597
- Wolf-Hirschhorn syndrome, 334
- Woman
- follicle-stimulating hormone level in, 628
 - prolactin level in, 990
 - testosterone in, 1084–1086
- Workplace screening, 544–547
- Worm parasite, 733
- Wound culture
- for bacteria, 492–497
 - white blood cell scan for, 1231–1233
- Wrist
- MRI of, 847

venipuncture of, 1255
x-ray of, 1027–1029

X

Xenon gas, 807–810
Xenon lung scan, 807–810
X-ray
 chest, 301–303
 skeletal, 1027–1029
 upper GI series and, 1172
D-Xylose tolerance test, 547–550
XXX Klinefelter's syndrome, 334

Y

Yersinia enterocolitica, 506–509

Z

Zenker's diverticulum, 587
Zidovudine (AZT), 881–883

Zinc, 1234–1236
Zinc deficiency, 1234
 alkaline phosphatase levels in, 25–26
 vitamin A and, 1228
Zollinger-Ellison syndrome
 alkaline phosphatase levels in, 25–26
 calcitonin stimulation test for,
 257–259
 D-xylose tolerance test for, 547–550
 fecal fat and, 606–608
 gastric acid stimulation test and,
 640–642
 gastric emptying scan for, 642–645
 gastrin stimulation test for, 645–647
 parathyroid hormone levels in,
 921–922
Zymogens, 338