

EDITION 4



Core Curriculum for **Infusion Nursing**

Mary Alexander

Ann Corrigan

Lisa A. Gorski

Lynn Phillips



Wolters Kluwer
Health

Lippincott
Williams & Wilkins

(c) 2015 Wolters Kluwer. All Rights Reserved.

Core Curriculum for **Infusion Nursing**

FOURTH EDITION

FOURTH EDITION

Core Curriculum for **Infusion Nursing**

INFUSION NURSES SOCIETY
NORWOOD, MASSACHUSETTS

E D I T O R S

Editor-in-Chief

Mary Alexander, MA, RN, CRNI®, CAE, FAAN

Chief Executive Officer
Infusion Nurses Society
Norwood, MA

Editors

Ann Corrigan, MS, BSN, RN, CRNI®

Customer Account Manager
PackRoom, LLC
Stone Mountain, GA

Lisa A. Gorski, MS, HHCNS-BC, CRNI®, FAAN

Clinical Nurse Specialist
Wheaton Franciscan Home Health & Hospice
Milwaukee, WI

Lynn Phillips, MSN, RN, CRNI®

Professor Emeritus, Butte College
Nursing Education Consultant
Chico, CA



Wolters Kluwer | Lippincott Williams & Wilkins
Health

Philadelphia • Baltimore • New York • London
Buenos Aires • Hong Kong • Sydney • Tokyo

Acquisitions Editor: Shannon Magee
Developmental Editor: Leslie H. Nicoll
Product Manager: Ashley Fischer
Production Project Manager: Marian Bellus
Design: Holly Reid McLaughlin
Manufacturing Manager: Beth Welsh
Production Services: Integra Software Services Pvt. Ltd.
Printer: RR Donnelley Asia

4th Edition

Copyright © 2014 Wolters Kluwer Health | Lippincott Williams & Wilkins.

Two Commerce Square
2001 Market Street
Philadelphia, PA 19103

Copyright © 2004, 2000 by Lippincott Williams & Wilkins. 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, photocopy, recording, or otherwise—without prior written permission of the publisher, except for brief quotations embodied in critical articles and reviews and testing and evaluation materials provided by the publisher to instructors whose schools have adopted its accompanying textbook. Printed in the United States of America. For information write Lippincott Williams & Wilkins, 530 Walnut Street, Philadelphia, PA 19106.

Materials appearing in this book prepared by individuals as part of their official duties as U.S. Government employees are not covered by the above-mentioned copyright.

9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in Publication Data

Core curriculum for infusion nursing / Infusion Nurses Society ; editor-in-chief, Mary Alexander ; editors, Ann Corrigan, Lisa A. Gorski, Lynn Phillips. — Fourth edition.

p. ; cm.

Infusion nursing

Includes bibliographical references and index.

ISBN 978-1-4511-8409-9

I. Alexander, Mary, 1955- editor of compilation. II. Corrigan, Ann, 1948- editor of compilation. III. Gorski, Lisa A., editor of compilation. IV. Phillips, Lynn Dianne, 1947- editor of compilation. V. Infusion Nurses Society, issuing body. VI. Title: Infusion nursing.

[DNLN: 1. Infusions, Parenteral—nursing—Outlines. 2. Fluid Therapy—nursing—Outlines. 3. Parenteral Nutrition—nursing—Outlines. WY 18.2]

RM170

615.8'55—dc23

2013007057

Care has been taken to confirm the accuracy of the information presented and to describe generally accepted practices. However, the authors, editors, and publisher are not responsible for errors or omissions or for any consequences from application of the information in this book and make no warranty, express or implied, with respect to the content of the publication.

The authors, editors, and publisher have exerted every effort to ensure that drug selection and dosage set forth in this text are in accordance with the current recommendations and practice at the time of publication. However, in view of ongoing research, changes in government regulations, and the constant flow of information relating to drug therapy and drug reactions, the reader is urged to check the package insert for each drug for any change in indications and dosage and for added warnings and precautions. This is particularly important when the recommended agent is a new or infrequently employed drug.

Some drugs and medical devices presented in this publication have Food and Drug Administration (FDA) clearance for limited use in restricted research settings. It is the responsibility of the health care provider to ascertain the FDA status of each drug or device planned for use in his or her clinical practice.

Contributors

Chapter 1: Technical And Clinical Application

Mary Alexander, MA, RN, CRNI®, CAE, FAAN

Chief Executive Officer
Infusion Nurses Society
Norwood, Massachusetts

Lisa A. Gorski, MS, HHCNS-BC, CRNI®, FAAN

Clinical Nurse Specialist
Wheaton Franciscan Home Health & Hospice
Milwaukee, Wisconsin

Ann Corrigan, MS, BSN, RN, CRNI®

Customer Account Manager
PackRoom, LLC
Stone Mountain, Georgia

Melody Bullock, MS, BSN, RN, CRNI®

Assistant Director Pediatrics and PICU
Cone Health System
Greensboro, North Carolina

Alicia Dickenson, RN, CRNI®

Staff Nurse
Tuality Healthcare
Hillsboro, Oregon

Ann Earhart, MSN, RN, ACNS-BC, CRNI®

Clinical Nurse Specialist-Vascular Access/Infusion Therapy
Banner Good Samaritan Medical Center
Phoenix, Arizona

Chapter 2: Fluid and Electrolyte Balance

Lynn Phillips, MSN, RN, CRNI®

Professor Emeritus, Butte College
Nursing Education Consultant
Chico, California

Chapter 3: Pharmacology

Michelle S. Turner, Pharm. D., BCPS

Clinical Pharmacist
Cone Health—The Moses H. Cone Memorial Hospital
Greensboro, North Carolina

Susan K. Poole, MS, BSN, RN, CRNI®, CNSNCIC

Principal
Southwest Horizons Consulting
Peoria, Arizona

Chapter 4: Infection Prevention

Mary McGoldrick, MS, RN, CRNI®

Home Care and Hospice Consultant
Home Health Systems, Inc.
Saint Simons Island, Georgia

Chapter 5: Pediatrics

Darcy Doellman, MSN, RN, CRNI®, VA-BC

Vascular Access Nurse
Cincinnati Children's Hospital Medical Center
Cincinnati, Ohio

Chapter 6: Transfusion Therapy

Deb Richardson, MS, RN, CNS

Vascular Access Consultant & Educator
President/Owner—Deb Richardson & Associates
Houston, Texas

Chapter 7: Antineoplastic And Biologic Therapy

Lynn M. Czaplewski, MS, RN, ACNS-BC, CRNI®, AOCNS®

Oncology Clinical Nurse Specialist
Columbia St. Mary's Hospital
Milwaukee, Wisconsin

Cora Vizcarra, MBA, RN, CRNI®

President/CEO
MCV & Associates Healthcare, Inc.
Indianapolis, Indiana

Chapter 8: Parenteral Nutrition**Elizabeth Krzywda, MSN, APNP**

Nurse Practitioner

Medical College of Wisconsin

Milwaukee, Wisconsin

Doug Meyer, RPh, MBA, BCNSP

Assistant Dean for Student Affairs

and Assistant Professor

Pacific University School of Pharmacy

Hillsboro, Oregon

Chapter 9: Quality Improvement**Grace Fletcher, MSN, RN, CRNI®, CPHQ**Director of Quality Assurance and Regulatory
Compliance

Vital Care, Inc.

Meridian, Mississippi

Preface

Recognized as the global authority in infusion therapy, the Infusion Nurses Society (INS) is dedicated to exceeding the public's expectations of excellence by setting the standard for infusion care. We set the standard by developing and disseminating standards of practice, advancing the specialty through evidence-based practice and research, and supporting professional certification.

The *Core Curriculum for Infusion Nursing* is an example of our commitment to education and certification. It is designed for use as a comprehensive, preparatory resource for clinicians taking the Certified Registered Nurse Infusion (CRNI®) exam administered through our sister organization, the Infusion Nurses Certification Corporation (INCC), and as a framework from which infusion-related educational programs and courses can be developed. With the current changes in health care in general and nursing in particular, it is imperative that the information contained within the *Core Curriculum* is accurate and current.

Historically, there have been nine major domains of practice identified as content categories. While the format of this edition of the *Core Curriculum* still has nine core content areas, INCC has made two changes. As a result of feedback received from a recent role delineation study, there will be eight content categories and a new domain "Special Populations" will replace "Pediatrics." The Pediatrics category was broadened to reflect the current practice and will be included in the Special Populations category along with topics related to older adults and pregnancy.

INCC conducts role delineation studies approximately every five years to survey infusion nurses about their practice, and update the examination detailed content outline (DCO) to reflect current practice. In the most recent role delineation study, completed in 2012, the Role Delineation Advisory Committee (RDAC) discussed whether the performance improvement topics and tasks should remain as a freestanding content category on the outline or be integrated throughout the outline. On the survey, eight topics were listed within the performance improvement domain, and those topics were rated by the survey respondents as significant to practice. Following discussion, the RDAC decided to drop "Performance Improvement" as a separate content category in favor of including items on performance improvement throughout the DCO to better reflect infusion nursing practice. Although not listed as a separate domain, the RN Examination Council will ensure that five to ten percent of the examination will cover performance improvement.

The goal of this revised edition of the *Core Curriculum* is to provide information related to new technological advances and the expansion of the specialty practice of infusion nursing. The information contained in each chapter provides a basis for the development of test questions for the CRNI® exam. In addition, a bibliography is supplied to provide the nurse with additional resources. The content of this publication is also suited for those seeking continuing education and professional development opportunities while providing a broader understanding of the specialty practice.

Whether it is in preparation to take the CRNI® exam or to expand one's knowledge base of the specialty practice, the *Core Curriculum for Infusion Nursing* is an invaluable resource. Certification, coupled with life-long learning, will enhance the fundamentals of nursing practice so that competent clinicians are delivering the safe, efficient, quality care that our patients deserve.

Mary Alexander, MA, RN, CRNI®, CAE, FAAN
Editor-in-Chief

Acknowledgments

INS recognizes the significance that the certification serves for the specialty practice of infusion nursing. Hence, providing reliable resources for potential exam candidates is critical for their success. Without our clinical editors and contributors, INS would not have been able to revise the *Core Curriculum for Infusion Nursing, 4th edition*.

I thank the authors for their thoughtful reviews and revisions. I appreciate their time, commitment, and contributions made to revise this edition of the *Core*.

I am especially grateful to the *Core's* clinical editors, Ann Corrigan, Lisa Gorski, and Lynn Phillips. At every phase of the revision process, they supported each contributor. As accomplished authors themselves, their knowledge and expertise were invaluable as we completed this project.

Lastly, I thank the Wolters Kluwer Health—Lippincott Wilkins & Wilkins staff for their professionalism and skill in improving this work. Of note, I'd like to recognize Leslie Nicoll, Developmental Editor, for her assistance with chapter reviews.

Mary Alexander, MA, RN, CRNI®, CAE, FAAN
Editor-in-Chief

Contents

Contributors v
Preface vii
Acknowledgments ix

CHAPTER 1
Technical and Clinical Application 1
*Mary Alexander, Lisa A. Gorski, Ann Corrigan,
Melody Bullock, Alicia Dickenson, Ann Earhart*

CHAPTER 2
Fluid and Electrolyte Balance 86
Lynn Phillips

CHAPTER 3
Pharmacology 131
Michelle S. Turner, Susan K. Poole

CHAPTER 4
Infection Prevention and Control 163
Mary McGoldrick

CHAPTER 5
Pediatrics 192
Darcy Doellman

CHAPTER 6
Transfusion Therapy 235
Deb Richardson

CHAPTER 7
Antineoplastic and Biologic Therapy 258
Lynn M. Czaplewski, Cora Vizcarra

CHAPTER 8
Parenteral Nutrition 309
Elizabeth Krzywda, Doug Meyer

CHAPTER 9
Quality Improvement 356
Grace Fletcher

Index 371

Technical and Clinical Application

Mary Alexander, MA, RN, CRNI®, CAE, FAAN

Lisa A. Gorski, MS, HHCNS-BC, CRNI®, FAAN

Ann Corrigan, MS, BSN, RN, CRNI®

Melody Bullock, MS, BSN, RN, CRNI®

Alicia Dickenson, RN, CRNI®

Ann Earhart, MSN, RN, ACNS-BC, CRNI®

Part I: Anatomy and Physiology



I. Vascular System

A. Cardiac Circulation

1. Heart
 - a. A hollow muscular organ made of four chambers that functions as a two-sided pump
 - 1) Right side is a low-pressure system pumping venous or deoxygenated blood to the lung
 - 2) Left side is a high-pressure system pumping arterial or oxygenated blood to systemic circulation
 - b. Right atrium (RA) is a thin-walled muscle that acts as a receiving chamber
 - 1) It receives systemic venous blood from the superior vena cava (SVC), which drains blood from the upper part of the body, and from the inferior vena cava (IVC), which drains blood from the lower extremities
 - 2) It receives blood from myocardial circulation by the coronary sinus
 - 3) Blood flow to RA occurs during inspiration
 - a) RA pressure drops below the pressure in veins outside the chest cavity
 - b) Blood flows from the area of high pressure to the area of low pressure
 - c. Right ventricle (RV) is the most anterior chamber of the heart, lying directly beneath the sternum
 - 1) Functions as both an inflow and an outflow tract

- 2) During diastole, blood enters the RV through the tricuspid valve and is ejected into pulmonary circulation through the pulmonic valve
 - 3) Systolic or ejection pressures of the RV may be low because of pulmonary resistance
 - d. Left atrium (LA) is the most posterior chamber of the heart
 - 1) It receives oxygenated blood from lungs via the right and left pulmonary veins
 - 2) Its wall is slightly thicker than that of the RA and exerts a pressure of 5 to 10 mm Hg with little breathing variation
 - e. Left ventricle (LV) is the chamber that lies posterior to and to the left of the RV
 - 1) Its wall is made of thick, muscular tissue; two to three times thicker than that of the RV
 - 2) Increased muscular mass is necessary to generate pressure to move blood into circulation
2. Cardiac valves
- a. The heart's efficiency as a pump depends on the integrity of the cardiac valves, whose sole purpose is to ensure one-way forward blood flow
 - b. Atrioventricular (AV) valves: positioned along the AV groove separating the atria from the ventricles
 - c. Tricuspid valve: located between the RA and the RV
 - 1) Larger and thinner than the mitral valve, with three separate leaflets: anterior, posterior, and septal
 - 2) Anterior and posterior leaflets associated with RV lateral wall function
 - 3) Septal leaflet attached to portions of the interventricular septum sitting in close proximity to the AV node
 - d. Mitral valve: located between the LA and the LV; composed of two cusps
 - 1) Anterior leaflet descends deep into the LV during diastole and rises quickly during systole to meet the posterior leaflet
 - 2) Posterior leaflet is smaller and more restricted in its motion
 - e. Semilunar valves: smaller than the AV valves
 - 1) Aortic semilunar valves
 - a) Located above the outflow tract of the LV
 - b) Composed of a fibrous supporting ring called the annulus and three-valve leaflet cusps that are thicker than those of the AV valves
 - 2) Pulmonic semilunar valve
 - a) Located above the outflow tract of the RV at the junction of the pulmonary artery and the RV
 - b) Composed of a fibrous supporting ring called the annulus and three-valve leaflet cusps
3. Nerve conduction
- a. Involves a special system consisting of atypical muscle fibers that transmit and coordinate electrical impulses throughout the heart
 - b. Sinoatrial (SA) or sinus node: located at the border of the SVC and the RA
 - 1) Gives rise to a self-generating impulse known as the heartbeat
 - 2) Primary pacemaker of the heart, generating impulses at a rate of 60 to 100 beats per minute (bpm)
 - 3) Innervated by sympathetic and parasympathetic nerve fibers
 - c. AV node: located in the RA
 - 1) Forms the conduction system of the heart
 - 2) Filters atrial impulses as they pass through the ventricles
 - 3) Innervated by the autonomic nervous system

- d. Bundle of His: located along the two sides of the intraventricular system, dividing into the right and left bundle branches and providing infranodal conduction
- e. Right and left bundle branches: located in the outer walls of the ventricles
 - 1) Conduction system of the heart working with the bundle of His and the Purkinje fibers to produce contraction of the ventricles
 - 2) Terminate in a fine network of conductive tissue called Purkinje fibers
- f. Purkinje fibers: fibers extending to the papillary muscles and lateral walls of the ventricles; located in the upper outer walls of the ventricles

B. Pulmonary Circulation

- 1. Blood flows from the RV to the lungs via pulmonary arteries and from the lungs to the LA via pulmonary veins
- 2. Major purpose is to deliver blood to the alveoli where oxygen is taken into the cells and carbon dioxide is removed

C. Systemic Circulation

- 1. Blood flows from the LV through the aorta and all its branches (arteries) to the capillaries of the tissues
- 2. Blood returns to the heart through veins and the vena cavae, which empties into the RA
- 3. Arteries
 - a. Layers
 - 1) Tunica intima: inner elastic endothelial lining consisting of smooth layers of flat cells
 - 2) Tunica media: middle layer consisting of muscular and elastic tissue
 - a) Strong layer that withstands pressure, preventing the collapse of vessels
 - b) Location of nerve fibers for vasoconstriction and vasodilation
 - c) Responsive to stimulation of chemical irritation by producing spasms that may cause a contraction, cutting off blood flow to surrounding tissues, and resulting in necrosis and gangrene
 - 3) Tunica adventitia: thick outer layer consisting of areolar connective tissue that provides vessel protection
 - b. Characteristics
 - 1) Contains bright red blood
 - 2) Pulsates
 - 3) Valves not present
 - 4) Usually located deep in tissue protected by muscle
 - 5) Branches terminate in arterioles, which form arterial capillaries
 - 6) Aberrant arteries—located superficially in an unusual place
 - c. Nerve conduction
 - 1) Sympathetic innervation: direct effect on arteries
 - a) Control of contraction and relaxation of muscle fibers within the vessels; vasoconstrictor fibers constrict vascular smooth muscle; vasodilator fibers relax vascular smooth muscle
 - b) Vascular reflexes are aided by chemical actions in regulating the diameter of the vessels to distribute the blood properly to tissues
 - 2) Parasympathetic innervation: indirect effect on arteries
 - a) Baroreceptors located in the carotid sinus and the aortic arch
 - b) Activated by impulses to heart, stimulating parasympathetic fibers causing a decrease in heart rate and dilation of arterioles

- d. Arteries appropriate for vascular access
 - 1) Radial artery
 - a) Direct continuation of the brachial artery beginning 1 cm distal to the bend of the elbow, descending along the lateral side of the forearm to the wrist
 - b) Usually considered site of choice for arterial line placement
 - 2) Ulnar artery
 - a) Large terminal branch of the brachial artery beginning just distal to the elbow and reaching the medial side of the forearm midway between the elbow and the wrist, and passing vertically, crossing the flexor retinaculum lateral to the ulnar bone
 - b) Larger, much deeper, and more difficult to stabilize than the radial artery
 - 3) Femoral artery
 - a) Artery located midway between the anterior superior spine of the ilium and the symphysis pubis
 - b) Largest accessible artery; easily palpated, stabilized, and entered
 - 4) Pulmonary arteries
 - a) Arteries leading away from the heart to the lungs
 - b) The left pulmonary artery is shorter and smaller than the right and runs horizontally in front of the descending aorta and the left principal bronchus to the left hilum, dividing into upper and lower lobar branches
 - c) The right pulmonary artery is longer and larger and runs horizontally to the right behind the ascending aorta, SVC, and upper right pulmonary vein, and then in front of the plexus
 - e. Advantages of use
 - 1) Diagnosis
 - a) Measurement of carbon dioxide and oxygen levels
 - b) Measurement of bicarbonate blood levels
 - 2) Continuous arterial monitoring
 - a) Systolic, diastolic, and mean arterial pressure readings
 - b) Assessment of cardiovascular effects of vasopressor and/or vasodilator drugs during the treatment of shock
 - c) Simultaneous drawing of arterial blood for arterial blood gases (ABGs)
 - f. Disadvantages of use
 - 1) Arterial spasms with resultant loss of circulation to an extremity
 - 2) Thrombosis with resultant loss of limb or life
 - 3) Threat of infection and septicemia
 - 4) Cardiac arrhythmias if catheter is placed in the RA
4. Veins
- a. Layers
 - 1) Tunica intima: inner elastic endothelial lining consisting of smooth layers of flat cells
 - a) Semilunar folds of endothelium form valves
 - b) Trauma during venipuncture encourages thrombosis, whereby cells and platelets adhere to vessel wall
 - 2) Tunica media: middle layer consisting of muscular and elastic tissue
 - a) Not as strong as in arteries; tends to collapse or distend as the pressure within vein falls or rises

- b) Location of nerve fibers for vasoconstriction and vasodilation: cold solutions result in spasms, impeding blood flow and causing pain; heat promotes vasodilation, relieving spasm, improving blood flow, and relieving pain; heat promotes dilation of vessels, reducing inflammation of vessel wall by increasing blood flow and diluting irritating medications or solutions
- 3) Tunica adventitia: outer layer consisting of areolar connective tissue providing vessel protection; not as thick as in the artery
- b. Characteristics
 - 1) Contains dark blood
 - 2) Does not pulsate
 - 3) Valves are present
 - 4) Located superficially
 - 5) Venous capillaries unite to form venules, which unite to form veins
- c. Nerve conduction
 - 1) Sympathetic innervation: direct effect on veins
 - a) Innervation by postganglionic efferent and primary afferent nerves
 - b) Controls contraction and relaxation of muscle fibers within vessel walls; vasoconstrictor fibers constrict vascular smooth muscle; vasodilator fibers relax vascular smooth muscle
 - 2) Parasympathetic innervation: indirect effect on veins
 - a) Baroreceptors located in carotid sinus and aortic arch
 - b) Activated by impulses to heart, stimulating parasympathetic fibers and causing a decrease in heart rate and dilation of venules
- d. Veins appropriate for peripheral infusion therapy
 - 1) Digital veins
 - a) Flow along the lateral portions of the fingers
 - b) From adjacent sides of digits unite to form three metacarpal veins
 - c) Last resort for therapy
 - 2) Metacarpal veins
 - a) Formed by the union of digital veins found on the dorsal aspect of the hand
 - b) Usually well adapted for infusion therapy
 - c) Occasionally contraindicated in the elderly because of inadequate tissue and thin skin in the area
 - d) Use in initial therapy enables successive venipunctures above previous sites, promoting availability of veins without inflammation and pain
 - 3) Cephalic vein
 - a) A large vein formed by metacarpal veins and located in the radial part of the dorsal venous network, flowing upward along the radial border of the forearm
 - b) Provides a natural splint for the placement of catheter
 - 4) Basilic vein
 - a) Originates in the ulnar part of the dorsal venous network, ascending along the ulnar portion of the forearm
 - b) Visualization is promoted by flexing elbow and bending arm upward
 - 5) Median antebrachial vein
 - a) Arises from venous plexus on the palm of the hand and extends upward along the ulnar side of in front of the forearm
 - b) Varies as to size and visibility

- 6) Intermediate (median) cephalic vein
 - a) A large vein located in the antecubital fossa
 - b) Typically used for blood withdrawal
 - c) Cautious use is necessary because the vessel crosses in front of the brachial artery
- 7) Intermediate (median) basilic vein
 - a) Located outside the antecubital fossa on the ulnar curve of the arm
 - b) Difficult to access for venipuncture
- e. Peripheral veins appropriate for central infusion therapy
 - 1) Basilic vein
 - a) Passes upward in a smooth path along the inner side of the biceps muscle and terminates in the axillary vein
 - 2) Brachial vein
 - a) Located between the basilic and cephalic vein
 - b) Runs close with the brachial nerve complex
 - c) Confluent with the basilic vein below the axillary vein
 - 3) Cephalic vein
 - a) Ascends along the outer border of the biceps muscle to upper third of the arm, passing in the space between pectoralis major and deltoid muscles, terminating in the axillary vein with a descending curve just below the clavicle
 - b) Occasional connection with external jugular or subclavian vein by a branch that passes from it upward in front of the clavicle
 - 4) External jugular vein
 - a) Easily recognized on the side of the neck; formed by the union of the posterior retromandibular and posterior auricular veins near the mandibular angle just below or in the parotid gland, descends to the midclavicle joining the subclavian vein
 - b) Threat of air being pulled into the vascular system if the administration set is accidentally disconnected
- f. Central veins appropriate for central infusion therapy
 - 1) Internal jugular vein
 - a) Begins at the cranial base in the posterior compartment of the jugular foramen and descends in the carotid sheath uniting with the subclavian, posterior to the sternal end of the clavicle to form the brachiocephalic vein
 - b) Often used when anomalies of the subclavian vein prevent use or in emergency situations when needed to administer large volumes of fluid quickly
 - c) Threat of air being pulled into the vascular system if the administration set is accidentally disconnected
 - d) Preferred as the site of insertion when the risk of thrombosis is higher than the risk of infection
 - 2) Subclavian vein
 - a) Continuation of the axillary vein extending from the outer border of the first rib to medial border of the scalenus anterior muscle, where it joins the internal jugular to form the innominate (brachiocephalic) vein
 - b) Clavicle and subclavius muscles lie anterior to the subclavian vein; subclavian artery lies posterosuperior, separated by the scalenus anterior muscle and the phrenic nerve; first rib and pleura lie inferior

- c) Vein of choice for the placement of central vascular access devices (CVADs) because of its easy accessibility in emergency situations and lower risk of infection
 - 3) Femoral vein
 - a) Continuation of the popliteal vein, ending posterior to the inguinal ligament at the external iliac and posterolateral to the femoral artery
 - b) Usually has four to five valves
 - c) Least favorable site for the placement of catheters
- g. Scalp veins used for infusion therapy
 - 1) Superficial temporal vein
 - a) Begins in a widespread network joined across the scalp to the contralateral vein and to the ipsilateral, supratrochlear, supraorbital, posterior auricular, and occipital veins
 - b) Ease in visualizing and has minimal risk
 - 2) Parietal vein
 - a) A branch of superficial temporal vein located in front of the ear
 - b) Usually not a vein of choice because of close proximity to the ear
 - 3) Occipital vein
 - a) A branch of temporal vein located behind the ear
 - b) Usually the last choice because of its location behind the ear
 - 4) Frontal (supratrochlear) vein
 - a) Originates on the forehead from a venous network connected to the frontal tributaries of the superficial temporal vein; metopic vein forms the section of frontal vein that runs down the center of the forehead
 - b) Most frequently used scalp vein
- h. Other veins used for infusion therapy
 - 1) Umbilical vein
 - a) Located within the umbilical cord through umbilicus to liver and ductus venosus
 - b) Frequently used for administering infusion therapy in newborns
 - c) Its use is limited because of the high risk of sepsis
 - 2) Great saphenous vein
 - a) Runs along the medial aspect of the leg from ankle upward across knee and thigh to enter femoral ring
 - b) Lower division above the ankle is frequently used in infants and toddlers
 - c) Not recommended for use in adults
 - d) Its use may require a licensed independent practitioner's (LIP's) written order
 - e) Originates with capillaries of superficial tissues of the foot; can lead to complications when used for infusion therapy
 - f) Thrombosis occurs more readily than when veins in upper extremities are used, leading to pulmonary emboli
 - g) More valves are present, creating the potential for medication to pool behind valves and creating irregular drug absorption
 - h) Patient immobilization potentiates pooling of blood in extremities
- 5. Capillaries
 - a. Minute blood vessels connecting the smallest arteries (arterioles) to the smallest veins (venules)
 - b. Exchange of nutrients and oxygen from the blood to the tissues with waste and carbon dioxide from the tissues into the blood (exchange vessels)



II. Integumentary System

A. Epidermis

1. Outer layer forms a protective covering
2. Thickness varies, depending on the body part and age
3. Provides support for an intravenous catheter

B. Dermis

1. Connective tissue layer supporting the epidermis
2. Highly vascular, providing nutrition for the epidermis
3. Contains capillaries and nerve fibers that react to temperature, touch, pressure, and pain

C. Superficial Fascia (Hypodermis)

1. A layer of loose connective tissue
2. Contains same collagen and elastin fibers as the dermis
3. Adipose tissue and fat cells are also found here and serve as energy stores and thermal insulators



III. Nervous System

A. Central Nervous System

1. Brain
 - a. A large mass of nerve tissue filling the cranium
 - b. Three connective tissue layers called meninges cover the brain and provide protection
 - 1) Dura mater: outermost double fibrous layer that separates the skull into compartments by its various folds or processes
 - 2) Arachnoid: middle layer made up of a two-layered fibrous elastic membrane that crosses over the folds and fissures of the brain, creating the spongy arachnoid space
 - 3) Pia mater: innermost layer rich in small blood vessels, supplying the brain with a large volume of blood
 - c. Anatomically divided into four components: cerebrum, cerebellum, brain stem, and ventricles
 - d. Cerebrum is the largest portion of the brain
 - 1) Comprised of gray cells and white matter
 - 2) Divided into hemispheres or lobes that are named according to overlying cranial bones
 - a) Frontal lobe
 - Located in the anterior fossa, extending from the anterior portion of each hemisphere to the central sulcus posteriorly
 - Controls psychic and higher intellectual functions and higher level centers for autonomic functioning, such as cardiovascular responses and gastrointestinal activity
 - b) Parietal lobe
 - Located in the middle fossa in the area between the fissure of Rolando and the parieto-occipital fissure
 - Major functions are position, sense, touch, and motor movement

- c) Occipital lobe
 - Pyramidal structure located in the middle fossa behind the parieto-occipital fissure just above the cerebellum
 - Contains the centers for vision
- d) Temporal lobe
 - Located in the middle fossa inferior to the lateral cerebral fissure and extends posteriorly to the parieto-occipital fissure
 - Responsible for primary functions of memory and hearing
- e. Cerebellum is approximately one-fifth the size of the cerebrum
 - 1) Functions primarily in coordinating movement, equilibrium, muscle tone, and position sense
 - 2) Consists of two lateral hemispheres and a middle portion, the vermis
 - a) Lateral hemispheres control the movement coordination for the same side of the body
 - b) Midbrain connects the cerebellum to the cerebral cortex
- f. Brain stem consists of the midbrain, the pons, and the medulla oblongata
 - 1) Midbrain (mesencephalon)
 - a) Forms a junction between diencephalon and pons
 - b) Functions to relay stimuli dealing with muscle movement, visual reflexes, and auditory reflexes from the spinal cord, medulla oblongata, and cerebellum to the cerebrum
 - 2) Pons
 - a) Connects the midbrain to the medulla oblongata
 - b) Relays impulses to brain centers and to lower spinal centers of the nervous system
 - c) Origin for sensory and motor nuclei of the trigeminal, abducens, facial, and acoustic nerves
 - 3) Medulla oblongata
 - a) Contains reflex centers for controlling involuntary functions such as breathing, sneezing, swallowing, coughing, salivating, vomiting, and vasoconstriction
 - b) Provides points of origin for the glossopharyngeal, vagus, spinal accessory, and hypoglossal nerves
- g. Ventricles are cavities located deep within the brain
 - 1) Filled with cerebrospinal fluid (CSF), which is produced mostly by lateral ventricles
 - 2) Connect with each other and with fluid spaces in the spinal cord through small openings
 - 3) Lateral ventricles serve as a site for the placement of Ommaya reservoir
- 2. Spinal cord
 - a. Ovoid column of nervous tissue extending through the spinal canal
 - 1) Originates at the foramen magnum and ends at the superior border of L₂
 - 2) Tapers in the lower thoracic area into a cone-shaped structure called the conus medullaris
 - 3) Anchored to the coccyx by the filum terminale, a thin prolongation of the conus medullaris
 - b. Serves as a center for spinal reflexes and a conducting pathway of impulses to and from the brain
 - c. Consists of gray (unmyelinated) and white (myelinated) matter
 - 1) Gray matter integrates the cord reflexes
 - a) Has an internal core resembling a butterfly on cross section

- b) Has a pair of projections forming the back wings—posterior or dorsal horns—consisting of multipolar neuron structures that form the motor efferent neurons of the ventral roots or spinal nerves
 - c) Contains cell bodies and dendrites of sensory neurons and sensory receptors from the periphery
- 2) White matter surrounds the gray matter
 - a) Consists of long ascending and descending tracts
 - b) Serves as the pathway between spinal cord and brain for afferent and efferent impulses, which are grouped into anatomical and functional bundles called fasciculi
- d. Divided into lateral halves, with each lateral half divided into three sections that run the length of the spinal cord: dorsal, lateral, and ventral
- e. Contains distinct fiber tracts
 - 1) Ascending fibers bring sensory information to the central nervous system
 - 2) Descending fibers carry impulses from the brain to motor neurons of the brain stem, spinal cord, and internuncial (association) neurons, which form short ascending and descending tracts that travel between spinal segments
- f. Protected by other structures
 - 1) Vertebral column
 - a) Runs from foramen magnum to sacral hiatus, with bony arches of the vertebrae posterior to the vertebral bodies forming a continuum to make up the spinal canal, with spaces between the vertebrae being taken up by spinal ligaments
 - b) Consists of 7 cervical, 12 thoracic, and 5 lumbar vertebrae with the sacrum and coccyx inferiorly
 - 2) Spinous processes
 - a) Prominent at the posterior part of each vertebra
 - b) Angulation varies and is an important consideration when inserting a needle into the epidural space
 - Processes almost horizontal in the cervical, lower thoracic, and lumbar regions; may require needle to be inserted at right angles to the sagittal plane
 - Processes directly caudal in the midthoracic region with maximal angulation between T₇ and T₈; may require needle to be inserted at varying degrees from the horizontal
 - 3) Spinal ligaments
 - a) Supporting structures that hold vertebrae together posteriorly
 - b) Provide access to the spinal canal
 - c) Supraspinous ligament runs superficial to tips of spinous processes
 - d) Interspinous ligament connects posterior spinous processes
 - e) Ligamentum flavum connects laminae of the vertebra
 - Tougher than other ligaments and easily identified by its increased resistance to needle insertion
 - Not present in the sacrum, where the laminae are fused together except at the fifth sacral vertebra, which has no laminae and thus forms the sacral hiatus through which the spinal canal may be entered when performing a caudal (sacral) block
 - 4) Other spinal ligaments
 - a) Anterior longitudinal ligament
 - Runs from skull to sacrum
 - Firmly attached to the discs and adjacent margins of vertebral bodies

- b) Posterior longitudinal ligament
 - Connects posterior aspects of the vertebral bodies
 - Forms anterior wall of the vertebral column
- 5) Meninges (three-layered membrane coverings)
 - a) Pia mater: membrane covering, closely attached to spinal cord and spinal nerves
 - Laterally attached to spinal nerve roots, eventually joining arachnoid and dura mater to become the connective tissue surrounding and investing the spinal nerves
 - Separated from arachnoid mater by the subarachnoid space, which contains CSF produced by the choroid plexuses in the brain ventricles
 - b) Arachnoid mater: thin membrane lying close to the dura mater but separated by the subdural space, which contains lymph
 - c) Dura mater: thick band of tissue covering spinal cord and its two coverings
 - Space between dura mater and vertebral column called the epidural space contains areolar tissue, fat, and a number of venous plexuses
- g. Supplied by numerous blood vessels throughout the epidural space that supply and drain blood from the vertebrae, the spinal cord, its coverings, and the spinal nerves

B. Peripheral Nervous System

1. Cranial nerves form the peripheral nerves of the brain
 - a. Divided according to function
 - 1) Five pairs have only motor fibers
 - 2) Three pairs have only sensory fibers
 - 3) Four pairs have both sensory and motor fibers
 - b. Correspond to the spinal nerves serving common sensation, voluntary control of muscles, and autonomic functions in the head, including the mechanism for the special senses of vision, hearing, smell, and taste
2. Spinal nerves: 31 pairs arise from different segments of the spinal cord
 - a. Each pair is formed by the union of anterior and posterior roots attached to the spinal column
 - b. Each pair with its corresponding part of the spinal cord constitutes a spinal segment
 - 1) Cervical nerves: four pairs join at anterior rami to form a complex network of nerve fibers called a plexus
 - a) Cervical plexus: first four pairs supply sensory and motor impulses to back of head, in front of neck, and upper part of shoulder to numerous neck muscles
 - b) Brachial plexus: latter four pairs supply sensory and motor impulses to scapula and muscles of upper extremities
 - 2) Thoracic nerves: 12 pairs with branches running directly to intercostal muscles and skin of thorax
 - a) Provide both sensory and motor impulses
 - 3) Lumbar nerves: five pairs extend obliquely and inferiorly, making up the lumbosacral plexus
 - a) Innervate lower extremities
 - b) Carry both sensory and motor impulses

- 4) Sacral nerves: five pairs
 - a) Four pairs emerge through the posterior sacral foramina
 - b) Fifth pair emerges through the sacral hiatus, carrying both sensory and motor impulses
- 5) Coccygeal nerves: one pair
 - a) Part of the lumbosacral plexus
 - b) Carry both sensory and motor impulses to the lower extremities

C. Autonomic Nervous System

1. Part of the peripheral nervous system that regulates the body's internal environment in close conjunction with the endocrine system
2. Responsible for the unconscious moment-to-moment functions of all internal systems, including visceral organs, involuntary fibers, and glandular functions
3. Activated by centers in the hypothalamus, brain stem, and spinal cord
 - a. Sympathetic nerves
 - 1) Consist of pre- and postganglionic nerve fibers arising from nerve cells in lateral column of gray matter of spinal cord
 - 2) Transmit impulses that cause an increase in blood pressure and heart rate and vasoconstriction of peripheral blood vessels when external stress situations occur
 - a) Most frequently termed the fight or flight reaction
 - b) Transmitter substance, norepinephrine, is secreted by postganglionic nerve terminals
 - b. Parasympathetic nerves
 - 1) Consist of preganglionic fibers arising from cell bodies in cranial nerves III, VII, IX, and X and spinal nerves II through VII
 - 2) Activated when the body is at rest or relaxed, and also protect and restore the body's resources



IV. Skeletal System

A. Functions

1. Bones collectively form the framework that supports the body; skeletal system enables the body to stand erect
2. Protects internal organs and other soft tissues
3. Assists movement by leverage and in coordination with muscles
4. Manufactures blood cells
5. Acts as reserves of minerals, particularly calcium and phosphorus

B. Bone Shapes

1. Short bones make up wrist and ankle
2. Flat bones make up sternum and scapula
3. Long bones comprise arm and leg
 - a. Consist of three parts
 - 1) Shaft, or long part of the bone
 - 2) Metaphysis, or flared part at the end of the shaft
 - 3) Epiphysis, or rounded end

- b. Epiphyseal cartilage
 - 1) Plate of soft tissue between epiphysis and metaphysis
 - 2) Provides growth
- 4. Irregular bones make up vertebrae and patella

C. Periosteum

- 1. All bones are covered with a double-layered connective tissue called periosteum
- 2. The outer layer of the periosteum
 - a. Contains blood vessels and nerves
 - b. Some penetrate into the inner structures of the bone through channels called Volkmann canals
- 3. The inner layer of the periosteum
 - a. Anchored to the bone by collagenous fibers (Sharpey fibers) that penetrate the bone
 - b. Sharpey fibers help hold or attach tendons and ligaments to the periosteum of bones

D. Intraosseous Space

- 1. Bone is made up of two types of bone tissue (osseous tissue)
 - a. Compact (cortical); makes up 85% of skeleton
 - b. Spongy (cancellous); makes up 15% of skeleton
- 2. Compact bone is highly organized, solid, and extremely strong
 - a. Basic structural unit in the compact bone is the Haversian system
 - b. Each Haversian system contains
 - 1) A central canal called the Haversian canal
 - 2) Concentric layers of bone matrix called lamellae
 - 3) Tiny spaces (lacunae) between the lamellae
 - 4) Bone cells (osteocytes) within the lacunae
 - 5) Small channels or canals called canaliculi
 - c. Each Haversian is a separate cylindric entity
 - d. The Haversian canal runs through the long axis of the bone
 - 1) Contains one or two blood vessels and nerve fibers
 - 2) The blood vessels in the canal communicate with blood vessels in the periosteum (surface cover) and marrow cavity to transport nutrition and wastes to and from the osteocytes contained within the lacunae
 - 3) Surrounding each Haversian canal are the concentric lamellae
 - 4) Between the lamellae are the lacunae; each contains one osteocyte
 - 5) The lacunae are connected to each other and to the Haversian canal by the canaliculi; run parallel to the horizontal axis of the bone
- 3. Spongy bone is less complex and lacks Haversian systems
 - a. The lamellae are arranged in plates or bars called trabeculae
 - b. Trabeculae branch and unite with one another to form an irregular meshwork. The pattern of meshwork is determined by the direction of stress on the bone
 - c. The space between the trabeculae is filled with red bone marrow
 - d. Osteocyte-containing lacunae are distributed between the trabeculae and interconnected by canaliculi
 - e. Capillaries pass through the marrow to nourish the osteocytes

Part II: Equipment



I. Solution Containers

A. Material

1. Glass
 - a. Necessary for certain solutions that are incompatible with or will leach through plastic
 - b. Easily broken when transported if caution is not taken to prevent breakage
 - c. Assess container in light before use; it is necessary to detect fine cracks through which microorganisms can enter
2. Plastic
 - a. Suitable for most solutions
 - b. Easily transported with minimal risk
 - c. Squeeze before use to detect punctures because bags are susceptible to punctures that may go undetected and allow microorganisms to enter

B. Volume Sizes

1. Containers for premixed solutions range from 50 to 1,000 mL
2. Plastic containers for use in preparing solutions are available that will hold as much as 4,000 mL (frequently used for parenteral nutrition [PN] solutions)

C. Types of Systems

1. Air-dependent (open system)
 - a. Refers to glass bottles that do not collapse as the solution leaves the bottle
 - b. Requires venting (air within system) for the solution to flow
 - 1) Air must enter the solution container through vented administration set or vented spike adapter
 - 2) The use of needles to vent solution containers is inappropriate because needles allow microorganisms to enter the solution increasing the risk for a bloodstream infection
2. Nonair-dependent (closed system)
 - a. Refers to plastic bags that collapse as the solution empties
 - b. Does not require air for the solution to flow
 - c. Reduces risk of air embolism and airborne contamination because of closed system

D. Nursing Considerations

1. Perform hand hygiene before opening or spiking solution containers
2. Inspect bags and bottles before use for cracks, leaks, damaged ports or seals, expiration date, clarity, discoloration, turbidity, and particulate matter; discard and report
3. Label bags and bottles with date and time when the solution container was opened
4. Cover solutions containing medications that are light-sensitive to prevent degradation of medication
5. Discard solution containers removed from the infusion system; do not save for later use; cover or remove label if it contains patient information



II. Administration Sets

A. Materials

1. Polyvinyl chloride (PVC) with di-2-ethylhexyl (DEHP)
 - a. Used for majority of administration sets
 - b. Not compatible with lipids and some medications
2. PVC without DEHP
 - a. Used for administration of lipids
 - b. DEHP is lipophilic and is extracted into the lipid solution
 - c. DEHP is considered a toxin
3. Non-PVC lined (polyethylene-lined)
 - a. Used for nitroglycerin administration

B. Types

1. Primary continuous administration set
 - a. Provides for administration of a primary solution
 - b. Does not provide measured volumes
 - c. May or may not have injection ports
 - d. Injection ports do not have a check valve, therefore, do not prevent solutions or medications from flowing back up the administration set and mixing with the primary solution
2. Secondary administration set
 - a. Typically shorter in length than the primary administration set
 - b. Used for the administration of piggyback medications
 - c. Attaches to the primary administration set at the Y-port above the back-check valve
 - 1) Flow-control slide clamp is an on-off clamp only
 - 2) Clamp is never used to regulate the flow of medication
3. Primary Y set
 - a. Allows alternate or simultaneous infusion of two solutions
 - b. May contain a filter or an in-line hand pump for the administration of blood
 - c. Use involves a hazard of air embolism because large quantities of air can be drawn into the administration set if one container is allowed to empty
4. Metered-volume chamber set
 - a. Contains a vented, calibrated chamber
 - b. May contain a microporous filter to block the passage of air when the chamber empties
 - c. Used frequently to measure solutions administered at a microdrip rate
 - d. Allows medications to be added directly into the chamber through the medication port
5. Specialty sets
 - a. Retrograde set
 - 1) Placed proximal to the infusion site
 - 2) Allows solution displacement within the set into a syringe as medication is injected into the set
 - 3) Allows administration of medication proximal to the site, eliminating loss of medication from adherence to the administration set
 - 4) Used to administer medications to neonates and pediatric patients

- b. Dedicated set
 - 1) Contains a specific segment that adapts to use with a specific infusion device
 - 2) Used only with devices for which it is designed
 - 3) May or may not allow priming outside of the infusion device

C. Characteristics and Features

- 1. Vented sets
 - a. Allows air to enter the system through a filtered vent
 - b. Required for glass containers
- 2. Nonvented sets
 - a. Do not allow air to enter the system
 - b. Used with plastic systems
- 3. Universal sets
 - a. Can be used with both glass bottles and plastic systems
 - b. Has a capped, filtered vent
 - 1) Opening the cap allows air to enter the solution container
 - 2) Keeping the cap closed prevents air from entering the solution container
- 4. Back-check valves
 - a. Allows the solution to flow in one direction only
 - b. Used to administer secondary ("piggyback") medications/solutions
 - c. Prevents mixing of primary and secondary solutions, or mixing of primary solution and medications administered through injection ports
 - 1) Primary solution is lowered on a wire or plastic hanger, creating greater head-height pressure for secondary solution
 - a) Secondary solution flows and primary solution stops
 - b) When the secondary solution is complete, primary solution flows automatically
 - 2) Risk of air entering the tubing between infusion of primary and secondary infusions is eliminated; occlusion due to interruption of infusion is prevented
 - 3) Rate of administration remains the same for both primary and secondary solutions when used without an infusion device because the flow rate is regulated by one clamp
- 5. Drop factor
 - a. Number of drops delivered in one milliliter (mL)
 - b. Macrodrop
 - 1) Set that delivers from 10 to 20 drops/mL
 - 2) Used to deliver solutions when critical measurement or small volumes are not required
 - c. Microdrop
 - 1) Set that delivers 50 to 60 drops/mL
 - 2) Used to deliver solutions when critical measurement or small volumes are required
 - d. Calculation of flow rate
 - 1) Determined by the use of a quick, easy formula:
$$\frac{\text{total mL} \times \text{drop factor}}{\text{total minutes}} = \text{drops/minute}$$

- 2) Consideration is given to the height of the solution container, blockage of or change in the position of the catheter, venous spasms, and viscosity of fluids because each has a direct impact on the drop size or the rate at which the drop may fall
6. Internal administration set diameter
 - a. Dictates the required priming volume of the set and is manufacturer-specific
 - b. Standard administration set
 - 1) Allows for infusion flow at a standard rate; have common inner lumen size with very little variation from manufacturer to manufacturer
 - 2) Routinely used for the administration of medications and solutions when critical measurement or small volumes are not necessary
 - c. Microbore administration set
 - 1) Inner lumen smaller than the standard set
 - 2) Used for administering infusions to neonates, pediatric patients, and volume-restricted adults
 - 3) Considered for use when small amounts are infused or a slow rate is desired
 - 4) Solution viscosity may decrease the flow rate
 - d. Macrobore administration set
 - 1) Inner lumen larger than the standard set
 - 2) The increased size of the lumen and drop size of the infusion allows for a rapid infusion flow
 - 3) Indicated when large amounts of fluid or blood are needed quickly, such as with trauma patients
7. Manual flow control devices: clamps
 - a. Device on administration set that allows the user to affect the flow rate of the solution by increasing or decreasing the diameter of the tubing
 - b. Roller clamp
 - 1) Uses a plastic roller to adjust the tubing diameter by applying pressure on the tubing, allowing regulation of the flow rate
 - 2) Used on most administration sets
 - 3) Requires time-consuming adjustments to establish and maintain the rate because changes in drop rate can occur after the rate has been regulated
 - c. Slide clamp
 - 1) Clamp that slides across the tubing to open or close the administration set
 - 2) On-off clamp only; should not be used to regulate the flow
8. Injection ports
 - a. Purpose
 - 1) To allow for the infusion of secondary solutions or medications; piggyback administrations
 - 2) To administer medications proximal to the site, such as with an "IV push" or bolus medication
 - b. Location
 - 1) Distal to drip chamber
 - 2) Proximal to the distal end of the administration set
 - c. Configuration and number vary with type and purpose of the administration set
 - d. Configured as a needleless port
 - 1) Needles are not used for the administration of medications/solutions

- 2) Provides a built-in safety feature or mechanism that effectively reduces the risk of an exposure incident when using the port
9. Connections
 - a. Luer
 - 1) Recommended method of connection
 - 2) Allows connection of administration set with an add-on device or a catheter by screwing together two compatible ends
 - 3) Deliberate twisting motion required to disconnect luer connection
 - 4) Prevents leaking at connections and accidental disconnections that place the patient at risk of infection, air embolus, and loss of blood through the catheter
 - b. Slip
 - 1) Allows connection of administration set with an add-on device or catheter by providing fittings that slide into each other and a tight connection when twisted
 - 2) Not recommended for use because it can be easily pulled apart, opening the system to airborne contaminants and possible free flow of blood externally

D. Nursing Considerations

1. Assess product and package integrity before use; do not use if violated
2. Assess patient for latex sensitivity; some administration sets contain parts with latex
3. Determine the appropriateness of the administration set based on medication/solution to be administered
 - a. Certain medications, such as Paclitaxel (Taxol), must be given through administration sets not made of PVC
 - b. Administration sets used to administer other medications such as propofol should be replaced every 12 hours, when vial is changed, or according to manufacturer's recommendations
4. Change primary and secondary administration sets in accordance with the *Infusion Nursing Standards of Practice* and organizational policies and procedures
5. Change administration sets at the time of the peripheral catheter change or when a new CVAD is placed
6. Treat secondary administration sets detached from a primary administration set as primary intermittent administration sets and change in accordance with the *Infusion Nursing Standards of Practice* and organizational policies and procedures
7. Place a sterile, compatible covering device to the male end of the primary intermittent administration set after each use
8. To administer lipid emulsions use sets free of DEHP
9. Label administration sets with the date and time of initiation
10. Maintain administration sets as closed systems
11. Disinfect injection ports prior to every use
12. Never flush or irrigate administration sets to improve flow rate
13. Change all administration sets with the catheter and solution container, if phlebitis, thrombophlebitis, cellulitis, or intravenous-related bacteremia is suspected
14. Use a needleless system when accessing the administration set



III. Add-on Devices and Needleless Connectors (NCs)

A. Purpose

1. To add length, filtering capabilities, or increase the overall function of the infusion system
2. Limiting their use reduces the incidence of contamination and accidental disconnection, minimizes the manipulation of the sterile pathway, maintains a closed system, and reduces costs associated with their use

B. Types of Add-on Devices

1. Extension sets
 - a. Features
 - 1) Used to add length to administration sets or to provide additional entry into the system
 - 2) May or may not have an on-off clamp
 - 3) May or may not have one or more Y ports for use when administering medications or solutions
 - b. Types
 - 1) Straight extension set
 - a) Frequently used to add length to administration sets or catheter
 - b) Extends catheter length to facilitate self-care for home infusion patients
 - 2) Y connector extension set
 - a) Forms a "Y"
 - b) Provides two entry points into system
 - c) Usually has a clamp on both segments of the Y, allowing solutions to run simultaneously or separately
 - d) May have injection ports or back-check valves in one or both segments to prevent solution backflow into either segment
 - 3) Multi-entry extension set
 - a) Set with three or more "pigtailed," allowing three or more entries into the system
 - b) May have clamps, additional injection ports, or check valves in one, two, or all of the segments
2. Stopcocks
 - a. Used to provide multiple entries into infusion system when additional access is needed or to provide an alternate entry into the system if an emergency arises
 - b. Available with or without an extension set and with varying types of ports, including needleless ports
 - c. Use is discouraged due to contamination risks
3. Catheter connection devices
 - a. A device used to connect the administration set to a catheter
 - b. Types
 - 1) T connector: shaped like a T usually connected to a short extension set with a slide or pinch clamp attached; frequently used in neonates, infants, and small children; allows safe disconnection of administration set without fear of backflow of blood or air emboli

- 2) J loops and U connectors: same intended use as T connectors; are rigid and hold their shape when attached to the catheter; predetermined shape creates a disadvantage if the insertion site is in an awkward location
4. Solid caps
 - a. Closed plastic casings used to cover injection ports, catheter hubs such as dialysis catheters, and the end of syringes filled with medications
 - b. Disinfection cap
 - 1) Impregnated with a sponge coated with an antiseptic solution; 70% isopropyl alcohol
 - 2) Designed to bathe the connection between accesses
 - 3) Protects the catheter hub from touch and airborne contamination
5. Needleless Connectors (NCs)
 - a. An add-on device designed to accommodate needleless devices for infusion administration
 - b. Types by design
 - 1) Simple NC group
 - a) Simple design with no internal mechanisms; straight fluid pathway
 - b) Prepierced septum with a blunt cannula or luer-lock design
 - 2) Complex NC group
 - a) A variety of luer-lock mechanical valves with internal mechanism designs and fluid pathways
 - b) Allows both injection and aspiration of fluids
 - c. Types by function
 - 1) Negative displacement: blood reflux into catheter lumen upon disconnection with movement of valve mechanism
 - 2) Positive displacement: small amount of fluid pushed out of the end of the catheter lumen, clearing any blood reflux resulting from disconnection of the administration set or syringe
 - 3) Neutral displacement: internal mechanism prevents blood reflux upon connection or disconnection

C. Nursing Considerations

1. Limit use due to the risk of contamination from manipulation, accidental disconnection, or misconnection
2. Connections should be of luer-lock design and compatible with the administration system
3. Change in accordance with the *Infusion Nursing Standards of Practice* and organizational policies and procedures
 - a. When the administration set is changed
 - b. Immediately suspected contamination or break in integrity
 - c. If blood or debris visible
4. When removed from a catheter or administration set, the device is discarded and a new device is attached
5. Assess compatibility of solutions/medications administered through each connection to prevent admixing of incompatible solutions/medications in the VAD
6. Ports should be capped when not in use; port cap is considered contaminated once removed; replace with a new sterile cover
7. Before accessing, disinfect ports with an appropriate disinfectant using friction



IV. Catheter Stabilization Devices

A. A device/system designed and engineered to control the movement at the catheter hub, decreasing catheter movement within the vessel and risk of catheter malposition

B. Purposes

1. To preserve the integrity of the access device
2. To minimize the catheter movement at hub
3. To prevent catheter dislodgment and loss of access

C. The method should not interfere with assessing and monitoring of access sites or impede vascular circulation or delivery of prescribed therapy

D. Preferred Alternative to Tape or Sutures to Secure Catheters

E. Protocols for use should be established in organizational policies and procedures and in accordance with manufacturer's guidelines



V. Filters

A. Features

1. A device that prevents the passage of air or undesired particulates
2. Product design determines the size of the particulates retained
3. Characteristics vary with the filter used; optimal characteristics include
 - a. Retention of particulates, bacteria, fungi, and endotoxin
 - b. Removal of air from system and vents to atmosphere
 - c. Nonbinding ability with drugs, allowing dosage to pass
 - d. Allowance for high-gravity flow rates
 - e. Pressure tolerance to withstand pounds per square inch (psi) of an electronic infusion device (EID)
4. Should not be used as a routine measure for prevention of infection

B. Types

1. In-line filter (filter that forms an integral part of the administration set)
 - a. Advantages
 - 1) Associated with less risk of contamination because filter is an integral part of administration set design
 - 2) No risk of separation
 - b. Disadvantages
 - 1) When placed in the upper part of the administration set, instead of at the distal end, retains only those substances that enter the set above the filter
 - 2) Entire set must be changed if filter becomes clogged

2. Add-on filter (filter added to an administration set)
 - a. Advantages
 - 1) Easily changed when filter becomes clogged or defective without removing the entire administration set
 - 2) Placed at the distal end of the administration set, removing all substances that enter the set above the filter
 - b. Disadvantages
 - 1) May be accidentally separated from the administration set or catheter, potentiating the risk of infection or possible hemorrhage
3. Filter needle/straw
 - a. Retains particulate matter >5 microns in size
 - b. Frequently used when preparing intravenous medications
 - c. Recommended when withdrawing medications from glass ampoules or multidose vials, particularly if the medication is to be administered as a bolus and cannot be administered through a bacteria-retentive filter

C. Structural Configuration

1. Depth filter: consists of fibers or fragmented material that has been bonded or pressed to form a tortuous maze
 - a. Cannot be given an absolute rating because the pore size is not uniform; assigned a nominal rating, the particle size above which 98% of the contaminants will be retained
 - b. Removes particulates only; does not remove air
2. Membrane filter: screen-type filter with uniformly sized pores that provide an absolute rating, retaining all particles on the membrane greater than its size
 - a. May retain bacteria and fungus, depending on the pore size
 - b. May have a unique membrane that removes endotoxins, microbial contaminants, particulate matter, and air; bacteria retained may break down after 24 hours and release bacterial toxin confined within the body of a bacterium
3. Hollow fiber filter: contains fibers that trap undesired substances
 - a. Provides a large filtering area that makes for easy priming and prevents clogging and binding of medications
 - b. Withstands pressures to 45 psi

D. Surface Area

1. Refers to area with which the solution or medication comes in contact
2. Affects flow rate
 - a. The larger the surface area, the greater the area through which fluid or medication can flow, increasing the flow rate
 - b. The smaller the area, the slower the rate

E. Pressure Limitations

1. Rated according to psi of pressure that can be exerted on the filter membrane without rupturing it
2. Consideration necessary before applying a positive-pressure EID; pressure of the infusion device should not exceed the psi of the filter

F. Indications for Use

1. Available in a variety of pore sizes, forms, and materials; pore size determines what substances are retained

2. 0.2-micron filter
 - a. Absolute bacteria-retentive, air-eliminating filter that removes particulates of 0.2 micron or larger
 - b. For nonlipid solutions that require filtration
 - c. Contraindicated for administration of blood/blood components; lipid emulsions; low-dose (<5 microns/mL), low-volume medications (total amount, <5 mg during 24 hours); IV push medications; medications in which the pharmacologic properties are altered by the filter membrane or bind to the filter membrane
 - d. Air-venting filters automatically vent air through a nonwetable (hydrophobic) membrane and permit uniform high-gravity flow rates through large wettable (hydrophilic) membranes, overcoming flow resistance
3. 1.0 micron filter
 - a. Removes particulates >1.0 micron; often termed a particulate matter filter
 - b. May be designed as an integral part of the administration set, as a membrane filter in a metered-volume chamber set, as an add-on device, or as a needle
 - c. May have air-eliminating properties
 - d. Recommended use
 - 1) Administration of infusions that contain medications with a pore size >1.0 micron
 - 2) Preparation or administration of solutions or medications to remove particulates that have the potential for obstructing vascular or pulmonary systems
4. 1.2-micron filter
 - a. Recommended for administering total nutrient admixtures
 - b. Usually has air-eliminating properties
5. 5 microns filter
 - a. Particulate matter filter removing particles >5 microns
 - b. Recommended for use when infusing or admixing medications or solutions with a pore size >5 microns

G. Nursing Considerations

1. Filters should be placed as close to catheter insertion site as possible to achieve final filtration
2. Application and placement should coincide with administration set change, and immediately if contamination is suspected or product integrity is compromised
3. Use should comply with manufacturer's directions for use
4. When using an EID, the psi rating of the filter should not exceed the psi exerted by the EID



VI. Vascular Access Devices (VADs)

A. Peripheral VADs

1. Needles
 - a. Stainless steel needle: hollow tube made of stainless steel, may have plastic wings to aid insertion
 - b. Used for single-dose medications and drawing of blood samples; not left in place as an indwelling device

- c. Less thrombogenic than catheters as a result of decreased formation of fibrin sheath around the needle
- d. Increased risk of infiltration, a concern if administering vesicant medications or solutions
- 2. Peripheral catheter
 - a. A term used to refer to a hollow tube made of plastic that is used for accessing the vascular system
 - b. Vary in gauge, length, composition, and design
 - c. Tip of a peripheral catheter terminates in a peripheral vein
 - d. Types
 - 1) Over-the-needle catheter: catheter with an internal needle stylet to facilitate venipuncture
 - a) The catheter is threaded into the vessel once venipuncture is made and stylet is then removed and discarded
 - b) The catheter of choice for peripheral infusion therapy anticipated to last 7 or fewer days
 - 2) Midline catheter: catheter between 3 inches (7.5 cm) and 8 inches (20 cm) in length
 - a) For intermediate-term therapies of 1 to 4 weeks
 - b) Inserted above or below antecubital fossa through basilic, cephalic, or median veins, with the tip residing below axilla in the larger vessels of upper arm, providing greater hemodilution
 - c) Catheter tip does not enter the central vasculature
 - e. Composition
 - 1) Teflon, PVC, polyurethane, or silicone
 - 2) Varies with regard to thrombogenicity or potential for producing vein inflammation
 - a) Teflon considered most thrombogenic
 - b) Silicone considered least thrombogenic
 - f. Properties
 - 1) Only radiopaque catheters are used so that in the event of a fragmented catheter, the catheter fragment can be visualized by radiography
 - 2) May be entirely radiopaque or may be clear with a radiopaque strip; radiopaque strips may promote insertion because of visibility of blood flow when the vein has been entered
 - 3) Has safety engineered mechanism to reduce the potential for exposure to blood-borne pathogens
 - a) Passive activation occurs without any action by the inserter to initiate the safety mechanism; preferred choice
 - b) Active activation requires the inserter to do something to initiate the safety mechanism
 - 4) Double-lumen catheter: a catheter that provides two entries into the vascular system with one venipuncture
 - a) Provides two separate lumens, one through which the needle stylet resides and a second that appears as a side port with a short extension, which allows exit of solution or medication through an outlet or "eye" above the distal end of the catheter
 - b) Each port provides independent flow of medications or solutions so that they never mix while infusing through the catheter

- g. Gauge and length
 - 1) Gauge refers to the actual lumen size or interior space of the catheter
 - a) Gauges range from 24 to 12 gauge
 - b) The larger the number, the smaller the lumen
 - 2) Lengths of short peripheral catheters range $\frac{5}{8}$ to 3 inches
- 3. Nursing considerations
 - a. Choice of a needle/catheter depends on vein accessibility, type and duration of therapy, and patient preference
 - b. Use smallest gauge, shortest length catheter that will accommodate the prescribed therapy
 - c. Assess patient's vasculature and estimate blood flow around the device to prevent potential complications

B. Central Vascular Access Devices (CVADs)

- 1. When placed in the upper extremity, the catheter tip resides within the SVC near its junction with the RA; for femoral placement, the tip resides in the IVC above the level of the diaphragm
- 2. Types
 - a. Nontunneled percutaneous catheter: a catheter inserted percutaneously through a needle or an introducer, or over a guidewire that has been threaded through the needle or introducer
 - 1) Risk of catheter puncture or shearing when inserting the catheter directly into vein through a needle; the catheter should never be retracted through needle at any time during the procedure
 - 2) The selection of a catheter depends on the duration of the therapy and patient need
 - 3) Used for continuous or intermittent infusions of short duration
 - 4) Includes peripherally inserted central catheter (PICC)
 - 5) Multilumen configuration available
 - b. Tunneled catheter: a catheter surgically placed by a LIP by tunneling the catheter under the skin from the vein entry point to an exit point on the chest wall; a Dacron cuff encircling catheter provides catheter stability and serves as a barrier to prevent infection
 - 1) Patient's vascular status, length of therapy, and patient's preference and ability to care for the catheter considered before placement
 - 2) Dual- and triple-lumen configurations are available to accommodate multiple therapeutic and diagnostic procedures
 - 3) Used for long-term therapies
 - c. Implanted ports
 - 1) Implanted VAD: plastic, stainless steel, or titanium housing (i.e. port) attached to a catheter surgically implanted under the skin by a LIP
 - 2) Noncoring needles: steel needles with angled and deflected points used to access implanted ports
 - a) Available in variety of gauge sizes and lengths
 - b) The length of the needle may be determined by the depth at which implanted port is placed or size of a patient; generally range from $\frac{1}{2}$ to $1\frac{1}{2}$ inch
 - c) The needle point slices the septum of the port on entry and during removal, preventing coring
 - d) Available in straight and 90° angle configurations, with or without extension sets

- 3) Catheter insertion sites
 - a) Jugular or subclavian veins are used for ports placed on the chest wall and threaded into the SVC
 - b) Cephalic or basilic veins are used for ports placed on an upper extremity and threaded into the SVC
 - 4) Considerations
 - a) Available venous access
 - b) Duration of therapy
 - c) Patient preference and ability to care for port
 - d) Catheter of choice by many patients because of the need for minimal care since it is implanted under skin
 - 5) Used for long-term therapies
 - 6) May be of single- or dual-lumen configuration
 - 7) Placement and removal is a medical act
3. Composition
 - a. Made of polyurethane or silicone
 - b. Vary as to thrombogenicity or potential for producing vein inflammation
 - c. Silicone considered least thrombogenic and most preferred
 4. Properties
 - a. Radiopaque so that catheter tip placement can be verified by radiography
 - b. Short-term nontunneled catheters may be impregnated or coated with chlorhexidine acetate, chlorhexidine/silver sulfadiazine, minocycline/rifampin, or silver ion to help reduce central line-associated blood stream infections (CLABSI)
 - c. Some CVADs are specifically designed to tolerate the high pressure required for rapid injection used in some CT scans
 5. Size and length
 - a. Dependent on catheter type and insertion site
 - b. Central catheters are referred to by French size; ranging from 5 to 12 French
 - c. Central catheters range in length from 5 to 25 cm
 - d. Catheter length should allow for tip placement in the vena cava
 6. Configuration
 - a. Lumens
 - 1) Single-lumen catheters: provide one port of entry into the vascular system
 - a) Less risk of CLABSI due to less manipulation with single lumen
 - b) Use is restricted because of only one entry point
 - 2) Multilumen catheters: provide two or more catheter lumens for multiple entries into the vascular system
 - a) Accommodate multiple therapeutic or diagnostic procedures
 - b) May increase the risk of CLABSI secondary to increased access/manipulations
 - b. Safety mechanisms: to reduce the potential for exposure to blood-borne pathogens
 7. Insertion techniques
 - a. Direct venipuncture: associated with insertion of central catheters directly into the vein, usually subclavian or jugular
 - b. Tunneled: associated with tunneling of the catheter from the entry point into the vein to an exit point on the chest wall
 - c. Implanted: associated with port implantation under the skin, usually on the chest wall, with the catheter being placed in the subclavian or internal jugular vein

- d. Peripherally inserted: insertion of a catheter usually into the basilic or cephalic vein at the antecubital fossa, with threading of the catheter into the SVC
8. Nursing considerations
 - a. Before use, tip location must be confirmed by chest radiograph
 - b. Remove upon unresolved complication, therapy discontinuation, or if deemed unnecessary



VII. Local Anesthesia

A. Purpose: to alleviate pain associated with procedure-related pain

B. Types

1. Transdermal analgesic cream or patch
2. Intradermal injection of 1% lidocaine hydrochloride solution
3. Iontophoresis technology: delivers drugs through the skin by using an electric current
4. Pressure-accelerated lidocaine

C. Nursing Considerations

1. Select the local anesthetic agent or a method that is the least invasive and carries the least risk for allergic reaction
2. Base selection on the patient's condition, needs, risks, and benefits associated with cannulation or port access



VIII. Navigational and Visualization Devices

A. Ultrasound Devices

1. Provide real-time imaging of the vein
2. Use requires special training and an understanding of the vascular system
3. Used for the placement of central catheters including PICCs; growing trend to use for the placement of midline and short peripheral catheters
4. Uses sound waves to locate structures in the human body
 - a. Two major components: the transducer and the imaging instrument
 - b. The transducer can be positioned to obtain a transverse or cross-sectional view of the vein or a longitudinal view

B. Catheter Location Systems

1. Electromagnetic tracking
 - a. Detects electromagnetic signal from guidewire transmitted to a monitor
 - b. Visible or audible alarm indicates the vicinity of the catheter tip
 - c. Limitation: confirms catheter is in the right direction, but no information about the correct location
2. Electrocardiogram (ECG) tracings
 - a. Uses intravascular ECG for real-time tip location; indicated for guidance and positioning

- b. Change in P wave indicates the catheter tip
 - 1) As the catheter passes the SA node, P wave increases in voltage, and upward spike indicates RA
- c. May be considered as an alternative to chest radiograph and fluoroscopy
- d. Disadvantages
 - 1) P wave not present (AF, atrial flutter, marked tachycardia)
 - 2) Close-ended PICCs (e.g., Groshong); valves may not open consistently leading to intermittent ECG reading
- 3. Vascular-positioning system
 - a. Uses a combination of intravascular ECG and Doppler ultrasound to provide real-time navigation as catheter advances through the vasculature
 - b. As the catheter tip approaches the heart, the use of an algorithm identifies its location
 - c. May be considered as an alternative to chest radiograph and fluoroscopy.

C. Light Devices

- 1. Visible light
 - a. Designed to find peripheral veins from high-intensity light source
 - b. Requires darkened room to eliminate competing light sources
 - c. Area of illumination depends on skin color
- 2. Transillumination
 - a. Used when the near-infrared light source is placed against the opposite side of the extremity
 - b. Hemoglobin absorbs the light and identifies arteries and veins as dark areas on the skin
 - c. Viewing scope, similar to night vision goggle is used to see the veins



IX. Flow Control Devices

A. Overview

- 1. Regulate the administration of parenteral solutions and medications
- 2. Considerations for appropriate device selection
 - a. Patient age, condition, and mobility
 - b. Prescribed therapy and type of VAD
 - c. Setting in which therapy is delivered

B. Mechanisms of Delivery

- 1. Volumetric pump
 - a. Calculates solution delivery by measuring the solution volume as it is displaced into a reservoir attached to the administration set
 - b. Types of action
 - 1) Syringe: piston withdraws and pushes the solution through the administration set
 - 2) Linear peristaltic: peristaltic fingers compress tubing in a wavelike motion, pushing solution through the administration set
 - 3) Filling and emptying of microreservoirs: filled and emptied in sequence and measured in hundredths of a milliliter
- 2. Syringe pump: syringe driven by a piston to deliver solutions
 - a. Rate set to deliver solution continuously, intermittently, or continuously and intermittently simultaneously

- b. Rate is controlled by the drive speed of the piston attached to the syringe plunger
 - c. For patient-controlled analgesia (PCA) or intermittent medication delivery, such as antibiotics
 - d. Delivery of minute amounts (as little as 0.01 mL/hour) of medications or solutions; ideal for use with infants and for maintaining patency of arterial lines
 - e. Volume is limited to the size of the syringe used in the device, usually a 60-mL syringe, but can be as small as 5 mL
- 3. Piston pump: piston action controls the flow of the solution
 - a. Usually requires a special dedicated administration set
 - b. Allows rates to be set to deliver fluids continuously, intermittently, or continuously and intermittently simultaneously
 - c. May operate by battery or electricity; compact and portable
 - 4. Drop sensor: a device used with an infusion device designed to count drops as they fall and thus calculate the volume of solution being administered
 - a. Confirms only the presence or absence of flow
 - b. Variation in the drop size may cause flow rate errors

C. Electronic Infusion Devices

- 1. Programmable device powered by electricity or battery used to regulate infusion rate and volume
- 2. Controller
 - a. Electronically controlled drop sensor device that delivers solutions with the aid of gravity; does not exert positive pressure greater than the head height of the infusion container
 - b. Regulates flow rate by counting the drops and transmitting the rate to the device that controls the tubing pressure, increasing or decreasing the tubing diameter to deliver the rate set on the controller
 - c. Has alarms that are activated when established flow rates are violated or when resistance is detected; useful for detecting infiltrations
 - d. Requires solution container be placed approximately 36 inches above the catheter insertion site to overcome venous resistance and operate properly
 - e. Reduces the potential for “runaways” and empty bottles and for repeated venipunctures associated with gravity feed systems
 - f. Maintains constant, accurate flow rate without pressure
- 3. Positive-pressure infusion pump
 - a. Infusion device that exerts pressure to overcome vascular resistance to administer medications or solutions
 - b. Average pressure is 10 psi, with up to 15 psi considered to be safe
 - 1) Pumps with pressures >15 to 20 psi should be used with extreme caution
 - 2) Ability to set variable pressure limits must be a consideration in choosing a device for the pediatric population and frail elderly patients
 - c. Used to deliver high or very low volumes; in high acuity situations and complex therapies
 - d. Delivers accurately as programmed in accordance with industry standard of $\pm 5\%$
 - e. Features vary with device
- 4. PCA pump
 - a. PCA is a method of pain control designed to allow the patient the ability to administer bolus doses of an analgesic as needed
 - b. Ability to deliver doses on demand; responds by delivering or denying the dose as determined by preset limits

- c. Mode of therapy
 - 1) Continuous
 - a) For the patient who needs maximum pain relief without the option of demand dosing
 - b) Used for epidural narcotic infusions, neonatal infusions, pain-control administration to patients unable to use the demand function
 - 2) Basal
 - a) Can be accompanied by intermittent doses requested by the patient
 - b) Designed to achieve pain relief with minimal medication, allowing the patient to remain alert and active without sedation
 - 3) Demand
 - a) Delivered by intermittent infusion when a button attached to the pump is pushed
 - b) Can be used alone or supplemented by a basal rate
- d. Must be programmed with a lock-out interval to prevent overmedication; lock-out interval ensures that over a set period the patient can receive only a prescribed dose of medication
- e. Built with extensive memory capability, including pump programming, any interventions by the patient or nurse, and times of intervention

D. Indications for Use

- 1. Critical drug dosing
 - a. Antiarrhythmics
 - b. Antihypertensives
 - c. Bronchogenics
 - d. Heparin (continuous)
 - e. Insulin (continuous)
 - f. Oxytocin
 - g. Vasopressors
 - h. Narcotics
- 2. Anesthetics
- 3. Arterial drug delivery
- 4. Electrolyte infusions
 - a. Concentrated potassium chloride solutions in 250 mL or less
 - b. Magnesium sulfate solutions
- 5. Patients requiring strict fluid restriction
- 6. High-volume infusions
- 7. Administration of PN solutions
- 8. Continuous antineoplastic therapy
- 9. Neonatal patients and consideration in pediatric patients based on age, therapy, diagnosis, and condition

E. Features

- 1. Alarms
 - a. Mechanisms designed to alert the user regarding pump conditions such as air in line, empty container, occlusion, or a drug programmed outside the recommended parameters
 - b. Other alarms may include machine malfunction, secondary medication infused, pressure limits met, door open, and low battery
 - c. Alarm will continue to sound until the condition is corrected appropriately; some alarms can be silenced while being corrected

2. Drug library
 - a. Internal library that contains profiles of medications with upper and lower limits, clinical advisories, drug incompatibilities, and dosing limitations
 - b. Provides for both hard and soft limits for the administration of medications, allowing the user to bypass soft limits if necessary and preventing the administration of a dosage larger than a hard limit
3. Controls: buttons or pads that can be pressed to turn the power on, set parameters, lower alarm sound, set occlusion detection limits, or silence alarms
4. Electronic operation
 - a. Operated by electricity or by an inner battery pack
 - b. Inner battery pack life is variable as to operation time and how battery is recharged; depends on pump used
 - c. Most pumps have an alarm system to indicate when the battery is low and when the pump needs to be connected to electricity
5. Battery operated
 - a. Operated by batteries that provide varied lengths of time, depending on the rate of infusion, type of battery used, and number of programs
 - b. Various sizes and weights; some are small enough to fit into the palm of the hand, and others are large enough to need a backpack or carrying pouch
 - c. Ideal for use with ambulatory patients and individuals receiving infusion therapy outside the institutional setting
 - d. Alarms alert user when batteries need to be replaced; appropriate battery replacement for operation necessary
6. Pressure considerations
 - a. Pumps provide pressure to deliver programmed infusion rates
 - b. Should not exceed the pressure of the filter in use because the filter membrane may rupture, allowing particulates and bacteria on the membrane to empty into the vascular system
 - c. Must be high enough to overcome the arterial pressure if being used on an arterial line
 - d. May allow variable pressure adjustments

F. Mechanical Infusion Devices

1. A device that uses a nonelectronic method to regulate infusion flow rates with no outside power source
2. Elastomeric device
 - a. A balloon safely encapsulated inside a rigid, transparent container that varies in shape and size
 - b. Made of soft, rubberized material capable of being inflated to a predetermined volume, with a solution of relatively small volume and a specific infusion time
 - c. Provides a tamper-proof port for the injection of medication into the balloon, preventing accidental opening and contamination
 - d. Provides an outlet port with preattached tubing or a hub to which a kink-resistant administration set can be attached
 - e. Used primarily for the administration of antibiotics and postoperative analgesia; can be used for the delivery of small-volume parenteral therapies such as chemotherapy medications
 - f. Commonly used in home infusion administration and for postoperative pain management

3. Spring-coil piston syringe
 - a. Piston syringe powered by a spring-coil in the absence of manual pressure to deliver medication or solution
 - b. Incapable of sensitivity to change or interference, such as increased resistance from infiltration
 - c. Syringes may be prefilled and frozen, depending on the medication
4. Spring-coil container
 - a. Uses a combination of a spring-coil and a collapsible, flattened disk to deliver medication
 - b. Multi-use, small-volume administration device
 - c. Used for home infusion therapy

G. Implanted Pumps

1. Surgically implanted to deliver medication continuously
2. Used for administration of chemotherapy and therapies that manage chronic pain
3. Refills are necessary at specific intervals, depending on the volume of the reservoir and the rate of administration

H. Nursing Considerations

1. Device selection
 - a. Safety features
 - 1) Anti-free flow mechanism (when door is opened or administration set is removed, fluid flow is stopped by a mechanical clamp usually initiated at the time the door is opened)
 - 2) Dose-error reduction system
 - 3) Audible alarms
 - 4) Appropriate grounding to prevent electrical hazards and interference from other electrical equipment
 - 5) Antitampering mechanisms
 - 6) Battery life and operation
 - 7) Accuracy of delivery
 - 8) Drug calculation capability
 - 9) In-line pressure monitoring
 - 10) Adjustable occlusion pressure levels
 - b. Type of therapy being administered
 - c. Patient mobility
 - d. Patient setting: in a homecare setting, the size, safety, cost, mobility, and type of VAD are critical when selecting a flow control device
2. Selection of the administration set
 - a. Universal set: one that can be used with any flow control device
 - 1) Standard set that can be used with or without the device as a gravity system
 - 2) Ability to prime with solution independent of flow control device
 - 3) Free-flow may not be prevented when removed from the device
 - b. Device-specific: a set that is designed to be used with a specific flow control device
 - 1) May or may not be primed and used independently from pump
 - 2) Usually provides a feature that prevents free flow when the set is removed from the infusion device

3. User knowledge includes but is not limited to indications for use, mechanical operation, troubleshooting, psi rating, and safe use
4. Controllers, nonpressure devices, or devices in which pressure can be controlled are considered the instruments of choice for administering vesicant medications
5. EIDs are recommended for use with therapies administered via CVADs
6. EIDs are considered an adjunct to nursing care and are not intended to alleviate responsibility for monitoring and ensuring the ordered flow rate
7. Do not rely on EID alarms to detect IV infiltration or extravasation as the alarms are not intended to detect disruption of the fluid flow pathway

Part III: Initiation of Infusion Therapy



I. Indications

- A. Maintain or replace body stores of water, electrolytes, vitamins, proteins, calories, or nitrogen in the patient who cannot maintain an adequate intake
- B. Restore acid–base balance
- C. Administer continuous or intermittent medications
- D. Replenish blood volume or administer blood components
- E. Administer intravenous anesthetics
- F. Administer diagnostic reagents
- G. Monitor hemodynamic function
- H. Maintain patent vascular access in case of an emergency
- I. Assist in pain management



II. Order for Infusion Therapy

- A. Necessary to initiate infusion therapy that order be obtained from a LIP
- B. Clarification of information: legible, clear, concise, complete, appropriate for patient, and signed and dated
- C. Verification of Information
 1. Solution: type, volume, rate, and medications including dosage and route
 2. Medications: type, dosage, rate, frequency, and route
- D. Verify compatibility of all medications with primary and secondary solutions prior to administration

- E. Use of standing orders or order sets is established by the organization**
- F. Verbal or telephone orders are to be signed within a time frame established by the organization; always “read back” a verbal/telephone order to verify information**
- G. Use only those abbreviations approved by the organization**



III. Patient Assessment

- A. Is performed to establish a baseline for monitoring reactions and response to therapy**

- B. Psychological Assessment**

- 1. Assesses patient's ability to comprehend and understand therapy
 - 2. Assesses patient's ability to maintain therapy
 - 3. Assesses cultural and ethical considerations
 - 4. Assesses patient's perception of pain

- C. Assessment of Appropriateness of Therapy**

- 1. Prescribed therapy evaluated in relation to the patient's history, laboratory values, clinical findings, and psychological assessment
 - 2. Initiation of therapy is delayed and the LIP notified if therapy appears inappropriate based on nursing assessment; nurses are not protected from liability for implementing orders when they know the orders are inappropriate



IV. Patient Preparation

- A. Patient Identification**

- 1. Required before the administration of the prescribed therapy
 - 2. Verify using two independent identifiers not including the patient's room or bed number
 - 3. Confirm a patient's identity with another nurse/significant other if the patient cannot respond or if the identification bracelet is absent

- B. Patient Education**

- 1. Overview
 - a. The patient is provided with information about the prescribed therapy, the plan of care, and expected or anticipated outcome(s) of therapy
 - b. Incorporates teaching methods based on an assessment of age, developmental and cognitive level, cultural influences, and language preference; takes into account factors such as current stressors, sensory deficits, and functional limitations that may affect the ability to learn
 - 2. Key components of patient education
 - a. Assessment of the learner

- 1) Identify the learner: patient, caregiver, or others
- 2) Assessment parameters
 - a) Needs
 - b) Level of comprehension/health literacy
 - c) Readiness and motivation to learn
 - d) Maturation level and age
 - e) Developmental/cognitive level
 - f) Cultural, social, religious, and economic factors
- 3) Sources of information
 - a) Interviews with patient, family, and other caregivers
 - b) Review of patient's medical record
 - c) Discussions with other healthcare team members involved in the patient's care
 - d) Observation of the patient
 - e) Restatement of information by the patient
 - f) Patient choice of instructional methods
- b. Teaching process
 - 1) To develop a teaching plan that is individualized to meet the needs of the patient, with input from the patient and caregiver
 - a) Based on patient goals, objectives, and desired outcomes
 - b) Written in behavioral terms
 - c) Clear and concise
 - 2) To identify materials to be covered
 - 3) To determine the sequence of the material
 - 4) To select teaching methods
 - a) Verbal instructions
 - b) Audiovisuals
 - c) Written instructions
 - d) Demonstration
 - e) Return demonstration
- c. Implementation
 - 1) Establish rapport to reduce anxiety and fear
 - 2) Incorporate a variety of teaching methods to reinforce concepts
 - 3) Use language the learner can understand; avoid using medical jargon and abbreviations
 - 4) Present information in small parts grouped together to promote learning and prevent learner overload
 - 5) Present the most important information first
 - 6) Ask questions frequently and encourage feedback to ensure comprehension
 - 7) Offer verbal praise to reward learning
 - 8) Adjust learning goals as necessary
 - 9) Frequently summarize teaching
- d. Evaluation
 - 1) Ongoing
 - a) Throughout implementation
 - b) At completion of each teaching session
 - 2) Patient outcomes (identified as indicators for measuring patient/learner education)
 - a) Verbalization of understanding of instructions and provided information

- b) Return demonstration of learned procedures
- c) Improved adherence to the therapeutic regimen
- d) Increased patient satisfaction
- e) Enhanced patient recovery
- 3) Revise teaching plan as necessary based on evaluations
- e. Documentation of education in patient's permanent medical record
 - 1) Narrative form
 - 2) Checklist

C. Informed Consent

1. Will be obtained by the healthcare provider who will perform the infusion procedure after discussion that includes details of the procedure, risks and benefits, alternatives, and potential complications associated with the treatment or therapy
2. The nurse's role, if not performing the procedure, is to verify that consent was obtained
3. The patient or the caregiver has the right to refuse treatment. In the event the patient is deemed incompetent or unable to give consent, the consent of a legally authorized representative is obtained
4. Contains the following elements:
 - a. Documents written at or below the fifth-grade reading level and provided in the primary language of the patient
 - b. Provision of a qualified medical interpreter or reader for patients with limited language proficiency, limited health literacy, and/or visual/hearing impairments
 - c. Dialog with patient/caregiver about the nature and scope of the procedure



V. Infusion Therapy via Peripheral VAD

A. Indications for Use

1. Short-term therapy that can be maintained by the peripheral route
 - a. Infusates with pH >5 and <9
 - b. Infusates with osmolarity <600 mOsm/L
2. Intravenous administration of medications and solutions
3. Maintenance of vascular access without infusion

B. Site Selection

1. The vein selected must accommodate the size and length of the catheter
2. Site selection is based on the following:
 - a. Patient's condition, age, diagnosis, and comorbidities
 - 1) Skin condition and its ability to support a catheter
 - a) Skin in an elderly patient may be too thin to support a peripheral catheter
 - b) Catheter should not be placed in areas where lesions, cellulitis, or weeping tissues are present
 - 2) History of breast surgery with axillary node dissection, after radiation to that side, or with lymphedema; or affected extremity from a cerebral vascular accident

- 3) History of chronic kidney disease stage 4 or 5; avoid forearm and upper-arm veins to preserve veins for potential AV fistula
- 4) In infants and children, history of procedures treating congenital cardiac defects that may have a decreased blood flow to the subclavian artery
- b. Vein integrity, size, and location
 - 1) Peripheral veins should be palpated to determine condition and size
 - 2) Avoid injured or sclerosed veins
 - 3) Avoid lateral surface of wrist for approximately 4 to 5 inches to reduce the potential for nerve damage
 - 4) Avoid areas of flexion unless no other access available
 - 5) Veins in the antecubital fossa should be reserved for PICCs and for drawing blood samples
 - 6) Veins in lower extremities of the adult patient should be avoided
 - a) Small veins in the lower extremities communicate with multiple venous networks and are located distal to the heart, predisposing the vessels to congestion of blood with pooling and subsequent inflammation, leading to the formation of emboli and thrombophlebitis
 - b) Catheter insertion site is changed as soon as an appropriate site can be established if it is necessary to use the veins of the lower extremities
 - 7) Site selection should be routinely initiated in the distal areas of the upper extremities, with subsequent cannulations made proximal to the previous cannulated site
 - a) Cannulation should not be performed in the involved extremity if unable to place the catheter proximal to the previous site
 - b) Assurance that bifurcations or articulations do not exist between two veins with the possibility of subsequent infiltration and/or extravasation can be made only by fluoroscopic study
 - c) Use of the opposite extremity after extravasation
 - 8) In adults, appropriate veins for use include metacarpal, cephalic, basilic, and median veins

C. VAD Selection

1. Select the most appropriate VAD that will deliver the prescribed therapy based on the following:
 - a. Patient's condition, age, and diagnosis
 - b. Vein integrity, size, and location
 - c. Type and duration of prescribed therapy
 - d. Patient's infusion history
 - e. Patient's preference for location, as appropriate
 - f. Ability and resources to care for the device
2. Use the smallest gauge and shortest length catheter that will accommodate the prescribed therapy; solution or medication is hemodiluted, decreasing venous irritation and subsequent vein inflammation
3. Larger catheter used in delivering viscous solutions or medications because smaller gauge catheter results in decreased flow rates
4. Length of therapy
 - a. Steel-winged devices limited to short-term, single-dose administration and blood sampling

- b. Peripheral catheters used for therapies intended for <7 days
- c. Midline catheters used for therapies anticipated for 1 to 4 weeks

D. Local Anesthesia

1. Consider the use of local anesthesia for VAD cannulation
2. Assess the patient for potential allergic reactions, tissue damage, or inadvertent injection of the drug into the vascular system during administration

E. Site Preparation

1. Prepare insertion site using Standard Precautions and an aseptic no-touch technique
2. Gloves should be worn to perform venipuncture
3. Protective equipment (goggles and gown) should be worn if splash is anticipated
4. Insertion site preparation
 - a. Excess hair is removed by clipping with single patient-use scissors or disposable-head surgical clippers; shaving is not recommended because of potential for causing microabrasions and increasing risk for infection
 - b. If skin is unusually dirty, site should be cleansed with soap and water before applying an antimicrobial solution
 - c. Single-unit-use antimicrobial should be used
 - d. Skin antiseptics
 - 1) Chlorhexidine/alcohol solution is preferred for skin antisepsis
 - a) Use a back-and-forth friction scrub at the site
 - b) Not recommended for infants under 2 months of age
 - 2) One or two percent tincture of iodine, iodophor (povidone–iodine), and 70% alcohol
 - a) Apply in a circular pattern starting at the intended insertion site working out
 - e. Surface area to be prepared is dependent on the size of extremity
 - f. Area of 2 to 4 inches in diameter is usually cleansed in the adult patient
 - g. Cleansed area should be as large as or larger than intended dressing
 - h. Excess solution at the site is not blotted; solution is allowed to completely air dry
 - i. Povidone–iodine must remain on skin at least two minutes and should not be removed with alcohol because alcohol has the ability to negate the effect of the iodine
 - j. Organic solvents (e.g., acetone or ether) should not be applied to the skin before catheter insertion or dressing change

F. Peripheral VAD Placement

1. Insert using aseptic technique
 - a. Catheter is considered contaminated if aseptic technique is compromised, as in an emergency situation
 - b. When placed in an emergency situation, catheter should be removed and replaced as soon as possible and no later than 48 hours
2. Only one VAD is to be used for each catheterization attempt
3. No more than two attempts at placement should be made by any one nurse as multiple attempts limit future vascular access and causes unnecessary pain
4. Inspect VAD for product integrity before use and discard if defective or if product integrity is compromised

5. Stylets should never be reinserted into a catheter or a catheter withdrawn through a needle because of the potential for severing or puncturing the catheter
6. Use of a tourniquet
 - a. Assess need for a tourniquet
 - 1) May not need one on certain patients with large veins
 - 2) Apply loosely or avoid use in patients who bruise easily, are at risk for bleeding, have compromised circulation, and/or have fragile skin or veins
 - b. Should be single-patient use and latex free
 - c. Should be applied at an appropriate location above the intended insertion site to impede venous but not arterial flow
7. Vein dilation techniques are evaluated to provide the most appropriate technique for the patient
 - a. Opening and closing of the fist forces blood into veins, causing veins to distend
 - b. Lightly tapping the vein helps to dilate the vessel
 - c. Holding the extremity in a dependent position below the level of the heart increases the blood supply within the veins
 - d. Heat application causes vasodilation
 - 1) Apply to the entire extremity for 10 to 20 minutes
 - 2) Maintain until venipuncture is performed
 - e. If using a blood pressure cuff, inflate to just below diastolic pressure
8. Consideration should be given to using bedside ultrasound-guided visualization to aid in vein identification and selection
 - a. Microintroducers allow for smaller gauge needle access when placing midline catheters
 - b. Ultrasound gives the practitioner more choice about the location for catheter placement
9. Venipuncture techniques
 - a. Direct or one-step method: catheter inserted directly into the vein with an immediate thrust through the skin
 - 1) Often used with large veins
 - 2) Possible formation of hematoma if used in small veins
 - b. Indirect method: insertion of the catheter through the skin below the point where the vein is visible; relocates the vein and the catheter is inserted into the vein
 - c. One-handed technique: the same hand that performs the venipuncture also withdraws the stylet while advancing the catheter into the vein
 - d. Two-handed technique: one hand performs the venipuncture and the opposite hand grasps the catheter hub while the hand performing the venipuncture withdraws the stylet and advances the catheter
10. Stabilize VAD with sterile tape, surgical strips, or a stabilization device
11. Apply dressing (e.g., tape and gauze, transparent semipermeable membrane [TSM]) over the insertion site
12. Label dressing
 - a. Date and time of insertion
 - b. Gauge and length of VAD
 - c. Initials of the inserter
13. Documentation
 - a. Gauge, length, and type of VAD

- b. Catheter insertion site by anatomical descriptors
- c. Local anesthesia, if used
- d. Insertion methodology, including visualization and guidance technologies
- e. Type of therapy, drug, dose, rate, time, and method of administration
- f. Date and time of insertion
- g. Number and location of attempts
- h. Patient's response to the procedure
- i. Any problems or difficulties encountered with the procedure
- j. Name and title of the clinician inserting the catheter
- k. Name and title of the clinician making an entry in the patient's permanent medical record if different from the clinician inserting the catheter (such as the catheter inserted by a LIP)



VI. Infusion Therapy via CVAD

A. Indications for Use

- 1. Infusion therapy duration anticipated to be >1 week
- 2. Short- or long-term therapies need to be given via a central route due to their potential to cause internal vein wall damage
 - a. Certain antineoplastic and antibiotic medications, vesicants, and known irritants
 - b. Parenteral nutrition
 - c. Infusates with a pH of <5 or >9
 - d. Infusates with osmolarity of >600 mOsm/L

B. Site Selection

- 1. The vein selected must accommodate the size and length of the catheter
- 2. Site selection is based on the following:
 - a. Patient's condition, age, diagnosis, and comorbidities
 - 1) Patients with bleeding disorders; low platelet count may preclude CVAD placement: PICCs may be placed due to less risk of bleeding than with other CVADs
 - 2) History of breast surgery with axillary node dissection or with lymphedema; or affected side from a cerebral vascular accident
 - 3) History of chronic kidney disease stage 4 or 5, avoid forearm and upperarm veins to preserve veins for potential AV fistula
 - 4) Collaborative discussion with the patient and LIP should take place related to the benefits and risks of using a vein in an affected extremity
 - b. Vein integrity, size, and location
 - 1) Avoid areas of pain upon palpation
 - 2) Avoid compromised veins (e.g., bruised, phlebitic, infiltrated, sclerosed, corded)
 - 3) Avoid areas for planned procedures
 - 4) Anatomical measurements should be taken to determine catheter length required to ensure full advancement of the catheter to the lower third of the SVC and the junction of the SVC and RA; with placement in the femoral vein, tip dwell should be in the IVC above the level of the diaphragm
 - c. Patient preference, activity, and lifestyle

- d. Site for PICC
 - 1) Veins above or below the antecubital fossa, including the cephalic, basilic, median cubital, and brachial veins
 - 2) For neonates and pediatric patients, additional sites include the temporal vein and posterior auricular vein on the scalp and the saphenous vein in the lower extremities
- e. Site for nontunneled and tunneled CVAD and implanted port
 - 1) Nontunneled CVAD
 - a) Subclavian vein is recommended in adults; there is no preferred site in infants and children
 - b) For patients with chronic kidney disease, the subclavian vein is not recommended due to the risk for central venous stenosis; the internal jugular vein is preferred
 - 2) Tunneled CVAD and implanted port: the site is selected after collaboration with the healthcare team and patient

C. CVAD Selection

- 1. Select the most appropriate CVAD that will deliver the prescribed therapy
 - a. An algorithm is helpful in determining CVAD selection
 - b. When using multilumen CVADs, consideration should be given to the fewest number of lumens needed to meet the required therapy
 - c. Devices designed to withstand high-pressure injections should be considered for patients whose anticipated therapy may include CT scans and MRIs with contrast
- 2. Duration of therapy
 - a. Nontunneled CVADs are used for short-term infusion therapies, generally in inpatient settings
 - b. PICCs are used for short- and long-term infusion therapies; commonly used for home, outpatient, and long-term care infusion needs
 - c. Tunneled catheters and implanted ports are used for long-term therapies
 - d. Limited peripheral venous access or administration of irritating infusates often necessitates the need for central access regardless of the duration of the therapy

D. Site Preparation

- 1. Maximal sterile barrier (MSB) precautions, including mask, sterile gown, sterile gloves, cap, protective eyewear, and large full-body drape, are to be used
- 2. A standardized checklist should be used to ensure adherence to recommended practices
- 3. Insertion site preparation
 - a. Excess hair is removed by clipping with single patient-use scissors or disposable-head surgical clippers; shaving is not recommended because of the potential for causing microabrasions and increasing risk for infection
 - b. If skin is unusually dirty, the site should be cleansed with soap and water before applying an antimicrobial solution
 - c. Single-unit-use antimicrobial should be used
 - d. Skin antiseptics
 - 1) Chlorhexidine/alcohol solution is preferred for skin antisepsis
 - a) Use a back-and-forth friction scrub at the site
 - b) Not recommended for infants under 2 months of age

- 2) One or two percent tincture of iodine, iodophor (povidone-iodine), and 70% alcohol
 - a) Apply in a circular pattern starting at the intended insertion site working out
- e. Cleansed area should be as large as or larger than intended dressing
- f. Excess solution at the site is not blotted; solution is allowed to completely air dry
- g. Povidone-iodine must remain on skin at least 2 minutes and should not be removed with alcohol because alcohol has the ability to negate the effect of the iodine
- h. Organic solvents (e.g., acetone or ether) should not be applied to the skin before catheter insertion

E. Local Anesthesia

1. Anesthetize the intended venipuncture site
2. Assess the patient for potential allergic reactions, tissue damage, or inadvertent injection of the drug into the vascular system during administration

F. CVAD Placement

1. Insert using aseptic technique and adhere to components of central line bundle (hand hygiene, chlorhexidine/alcohol solution for site preparation, MSB precautions, avoid femoral vein insertion site in adults)
2. Ultrasound is used to reduce the number of attempts, failure rate, and complications
3. Seldinger or modified Seldinger technique is the preferred method for CVAD insertion
 - a. Decreases vein trauma
 - b. Decreases insertion complications
 - c. Decreases the risk of arterial puncture or nerve injury
4. Verification of tip location is done prior to use of newly placed CVADs and whenever repositioning or manipulation has occurred
 - a. May be done radiographically or by other approved technologies
 - b. Verification of tip location by a nurse is established in organizational policies and procedures
5. Placement of a CVAD by a nurse should be established in organizational policies, procedures, and/or practice guidelines and in accordance with state's Board of Nursing rules and regulations
6. Implanted ports/tunneled CVADs are placed in surgery/radiology by a LIP
7. Documentation
 - a. Gauge, length, and type of VAD
 - b. Catheter insertion site by anatomical descriptors
 - c. Local anesthesia, if used
 - d. Insertion methodology, including visualization and guidance technologies
 - e. Type of therapy, drug, dose, rate, time, and method of administration
 - f. Date and time of insertion
 - g. Number and location of attempts
 - h. Patient's response to the procedure
 - i. Any problems or difficulties encountered with the procedure
 - j. Name and title of the clinician inserting the catheter
 - k. Name and title of the clinician making an entry in the patient's permanent medical record if different from the clinician inserting the catheter (such as catheter inserted by a LIP)

Part IV: Routine Care and Maintenance



I. Patient Assessment

- A. Ongoing assessment is to be performed to monitor reactions and response to therapy
- B. An individualized plan of care, including assessment, diagnoses, interventions, and outcome criteria will be established, evaluated, and revised as needed



II. Site Care

A. Site Assessment

- 1. Site care
 - a. Routine for CVADs, midline catheters
 - b. Defined as aseptically cleansing the skin–catheter junction with an approved antimicrobial solution and applying a sterile dressing
 - c. Coincides with a change in dressing
 - d. Is a measure of infection prevention
- 2. Observe and evaluate skin–catheter junction, surrounding tissues
- 3. Application of antimicrobial ointment is not recommended due to possible promotion of fungal infections and antimicrobial resistance
- 4. All VADS: assess catheter insertion site and surrounding area for signs of local complications
 - a. Local complications appear at or near the catheter insertion site
 - 1) Infiltration
 - 2) Extravasation
 - 3) Phlebitis
 - 4) Ecchymosis
 - 5) Hematoma
 - 6) Site infection
 - 7) Nerve injury
 - b. Should be observed for visual signs/symptoms and palpated for swelling, warmth, tenderness, and drainage
- 5. Frequency of inspection is determined by the type of infusion therapy, patient condition/acuity and age, and practice setting; recommendations for infusions running via a peripheral IV catheter site include:
 - a. At least every 4 hours in adults who are alert and oriented and able to report problems and who are receiving nonirritating solutions
 - b. At least every 1 to 2 hours in adults who are critically ill, who have cognitive/sensory deficits, who are receiving sedative type medications, and/or who have catheters placed in a high-risk location such as the external jugular vein or any area of flexion
 - c. At least every hour in neonatal and pediatric patients
 - d. Every 5 to 10 minutes for patients receiving vesicant infusions, including vasoconstrictors
 - e. With every home visit for home care patients; patient education should address frequency of checking, what/how to report

B. Dressing Change

1. Routine for CVADs, midline catheters
2. Aseptic application is used to minimize the potential for microorganisms to breed under the dressing
3. Will be performed when the dressing is compromised, drainage or blood is present, or for further assessment if site infection or inflammation suspected
4. Assess dressing for dryness and occlusiveness; dressing should be replaced if damp, loose, or visibly soiled
5. Sterile gauze dressing
 - a. Change every 2 days
 - b. Entire surface and all edges are secured with tape to maintain occlusive, intact dressing
 - c. If gauze is placed under a TSM dressing, it is considered a gauze dressing and changed every 2 days
 - d. Use of roller bandages is not recommended because of the potential for impaired circulation and inability to assess catheter insertion site
6. TSM dressing
 - a. A sterile dressing that allows moisture to pass through the dressing away from the skin while preventing external moisture from contacting the VAD insertion site
 - b. Allows direct observation of insertion site
 - c. Tape over the TSM dressing may compromise dressing properties and interfere with visual inspection of the skin–catheter junction site
 - d. Frequency
 1. Short peripheral catheters: when catheter is replaced
 2. CVADs, midline catheters: every 5 to 7 days
 - e. Consideration may be given to using a chlorhexidine-impregnated dressing in patients older than 2 months of age to reduce the potential for infection



III. Flushing and Locking

A. Flushing

1. The act of moving fluids, medications, blood, blood products, and nutrients out of a VAD into the bloodstream, ensuring delivery of those components and verifying device patency
2. VADs are to be flushed prior to each infusion as part of the steps to assess catheter function and after each infusion to clear the infused medication from the catheter lumen, preventing the contact between incompatible medications
3. Single-use systems, including single dose vials or pre-filled syringes, are preferred
4. The flushing solution, concentration, volume, and frequency are established in organizational policy and procedure and in accordance with manufacturers' directions for use.
 - a. Preservative-free 0.9% sodium chloride (USP) is the preferred solution for short peripheral IV catheters
 - b. If medication is incompatible with preservative-free 0.9% sodium chloride (USP), 5% dextrose in water should be used followed by preservative-free 0.9% sodium chloride (USP)

5. Minimum volume of flush solution depends upon the type and size of catheter, age of patient, and type of infusion therapy being given
 - a. A minimum volume of twice the internal volume of the catheter system is recommended
6. In the neonate, solutions for flushing should not contain the preservative benzyl alcohol
7. The frequency of flushing VADs is established in organizational policies and procedures
8. A VAD should never be forcibly flushed; to prevent damage, the patency should be assessed using a 10 mL syringe

B. Locking

1. The instillation of a solution into a VAD to maintain device patency
2. VADs should be locked after completion of the final flush solution to decrease the risk of occlusion
3. Single-use systems, including single-dose vials and prefilled syringes, are preferred
4. Short peripheral catheters should be locked with preservative-free 0.9% sodium chloride (USP) following each catheter use in adults and children
5. If heparin solution is used, the potential for heparin-induced thrombocytopenia (HIT) must be assessed
 - a. Alternative locking solutions may be considered in patients with CVADs and HIT including, ethanol, sodium citrate, taurididine, ethylenediamine-tetraacetate, or combinations of these solutions
6. In the neonate, solutions for locking should not contain the preservative benzyl alcohol



IV. Administration Sets and Add-on Devices

A. Indications for Set Change

1. At established intervals, depending on the type of administration and infusate
2. Coincide with peripheral VAD replacement
3. Immediately when contamination is suspected or when product integrity is compromised

B. Set Change Frequency by Administration Type

1. Continuous infusion: change primary and secondary sets no more frequently than every 96 hours
2. Intermittent infusion: change primary and secondary sets every 24 hours

C. Set Change Frequency by Infusate

1. Blood and blood components: continuous or single unit, change set at the end of 4 hours
2. Intravenous fat emulsion (IVFE): continuous or single unit, change set every 24 hours
3. Parenteral nutrition
 - a. Cyclic or intermittent: change set every 24 hours

- b. Continuous with IVFE: change set every 24 hours
- c. Continuous without IVFE: change set every 96 hours
- 4. Propofol: continuous or intermittent change set every 12 hours

D. Add-on Devices and Needleless Connections

- 1. Disinfect before use with an antimicrobial solution, usually 70% alcohol but may also include 2% tincture of iodine, 10% povidone-iodine, alcohol, or chlorhexidine
- 2. Check the integrity of the port before each use
- 3. Discard when removed from the system; do not reuse



V. Solution Container

A. Inspect Before Use

- 1. For clarity and presence of particles
- 2. Squeeze bags to detect leaks
- 3. Hold bottles in the light and rotate to detect cracks
- 4. Verify expiration date

B. Frequency of Change

- 1. To add sequential containers, to avoid exceeding “hang time,” or in response to a change in therapy
- 2. Change if contamination is suspected or product integrity is compromised
- 3. Once administration set is attached or medication added to the container, container must be used or discarded within 24 hours

Part V: Termination of Therapy



I. Overview

A. Assessment includes: patient need, response to therapy, and achievement of expected outcome

B. LIP order needed to discontinue therapy

C. Patient or legally authorized representative refuses to continue therapy or requests to discontinue therapy



II. Catheter Removal

A. General Principles

- 1. VADs are removed upon unresolved complications, therapy discontinuation, or if deemed unnecessary
- 2. VADs placed in an emergency situation should be replaced as soon as possible and not later than 48 hours

3. CVADs should not routinely be exchanged or replaced
4. Aseptic technique is used to prevent bacteria from entering the catheter insertion site
5. Catheter integrity is assessed on removal
6. Catheter defects are to be reported to the manufacturer and regulatory agencies

B. Peripheral: Short

1. Frequency of short peripheral catheter removal for the purpose of site rotation is established in organizational policies and procedures
2. Requires application of digital pressure and a dry, sterile dressing to the site

C. Peripheral: Midline Catheter

1. Optimal dwell time is unknown; generally used for therapies prescribed for a duration of 1 to 4 weeks
2. Longer dwell times should be based on the professional judgment of the clinician after consideration of certain factors
 - a. Length and type of therapy remaining
 - b. Patient's peripheral venous status
 - c. Patient's condition
 - d. Condition of the vein in which catheter resides
 - e. Skin integrity
3. Caution should be used in catheter removal, particularly when the catheter has remained in place for an extended time period
4. If resistance is encountered, do not use force in an attempt to remove, and also notify the LIP
5. Requires the application of digital pressure and a sterile gauze dressing with petroleum-based antiseptic ointment to the access site to seal the skin-to-vein tract and decrease the risk of air embolus

D. Nontunneled CVADs

1. Daily assessment for necessity and removal when no longer required; two elements of the central line bundle aimed at reducing risk of infection
2. Need to be aware of potential complications associated with CVAD removal and be prepared to initiate emergency measures
 - a. Measures to reduce the potential for air embolism
 - 1) Position patient in supine position ensuring that the CVAD is at or below the level of the heart; have patient perform valsalva maneuver unless contraindicated
 - 2) Apply digital pressure until hemostasis is achieved
 - 3) Apply sterile gauze dressing with petroleum-based ointment to the access site to seal the skin-to-vein tract
 - b. Other potential complications, include but are not limited to, catheter embolism, pulmonary embolism, and excessive bleeding
4. Notify the LIP if resistance is encountered; do not use force in attempt to remove

E. Tunneled CVAD and Implanted Ports

1. Tunneled CVAD: removal of tunneled CVADs established in organizational policies, procedures, and/or practice guidelines and in accordance with state's Board of Nursing rules and regulations

2. Implanted port: removal is considered a surgical procedure and is performed by the LIP within the state's rules and regulations for professional practice and in accordance with organizational policies, procedures, and/or practice guidelines



III. Documentation

A. Date and Time

B. Observations

1. Objective: those visualized or palpated, including complications
2. Subjective: those stated by the patient/significant other/caregiver
3. Cardinal: diagnostic studies relative to therapy, such as laboratory work

C. Procedures Performed

D. Catheter Integrity and Length

E. Complications of Removal and Interventions Employed

F. Cultures, If Needed

G. Type of Dressing Applied

H. Patient Response to Therapy and Procedure(s)

I. Name and Title of the Clinician Performing the Procedure(s)

PART VI: Complications and Interventions



I. Complications

A. Overview

1. Complications can occur at any point in the life of a VAD, from insertion to removal
2. A VAD should be removed immediately if a catheter-related complication is suspected unless the complication can be safely resolved
3. The need for a VAD should be assessed on a daily basis and the VAD is removed immediately when no longer needed to reduce the potential for catheter-related complications

B. Effects of Complications

1. Delay/interruption in treatment
2. Potential for increased length of stay or extended length of treatment
3. Potential for increased costs of hospitalization and treatment
4. Vascular damage and reduced vessel use in the future, possible loss of access
5. Patient dissatisfaction

6. Potential decrease in patient mobility
7. Pain and illness
8. Potential for impaired quality of life
9. Places patient at risk for other medical problems



II. Local Complications

A. Overview

1. Usually seen at or near site, or occurs as a result of mechanical failure
2. Immediate recognition of associated signs and symptoms along with prompt intervention can prevent more serious complications
3. Report complications in accordance with organizational policy and procedures

B. Mechanical Complications

1. Insertion site: check for swelling above, over, and below the site to rule out site-related problems, such as infiltration/extravasation
2. Catheter: observe in relation to fluid flow
 - a. Catheter against vessel wall: causes fluid flow to decrease or stop
 - 1) Pulling back slightly on catheter can eliminate the problem
 - 2) Securing catheter to prevent movement within the vessel may prevent problems
 - b. Kinked or bent catheter: causes fluid flow to decrease or stop
 - 1) Remove catheter to prevent possible catheter breakage and subsequent catheter embolus
 - 2) Appropriate securement and stabilization prevent bending or kinking of catheter
 - c. Catheter in the area of flexion: may cause fluid flow rate to increase or decrease as a result of movement of the involved extremity; may increase the risk of phlebitis, infiltration, and catheter dislodgement
 - 1) Avoid catheter insertion sites in areas of flexion
 - 2) Flexion and extension of extremity after the insertion of the catheter can aid in the detection of a positional catheter; fluid flow increases and decreases with flexion and extension
 - 3) Stabilize joint (e.g., arm board) if catheter must be placed in area of flexion
3. Defective catheter: may leak at the catheter–hub junction, compromising the dressing or obstructing fluid flow
 - a. Remove catheter; save catheter along with the package; manufacturer should be notified
 - b. Some manufacturers require the catheter to be returned so that they can check for defects; others require only the lot number be saved
4. Solution container: check for appropriate volume
 - a. Time-taping solution containers is helpful in noting when a container should be emptied
 - b. Lack of adequate gravity flow: maintain solutions at a level to promote optimal flow
 - 1) Hang solution at least 30 inches above the level of the heart for adequate gravity flow
 - 2) Increase the height of viscous solutions to obtain the adequate flow rates as necessary

- c. Air vent: some solution containers (most bottles) require air for adequate flow
 - 1) Vented or universal administration set or vented adapter allows exchange of air and fluid, permitting solution flow
 - 2) Bags do not require venting because they collapse as solution flows from bag
 - 3) Needles are inappropriate to use as a vent because they provide a potential site for microorganisms to enter into the vascular system
 - d. Bag-entry ports: solution cannot pass through an obstructed port or an administration set spike that has not penetrated the port seal
 - e. Solution temperature: administration of cold solutions may produce vasospasm, causing vasoconstriction with a decrease in solution flow; solutions other than blood and blood components should be removed from the refrigerator and allowed to reach room temperature before being administered
5. Administration set
- a. Pinched, kinked, or crimped administration set
 - 1) Creates inaccurate flow rate or stops solution flow
 - 2) Loop and tape set to avoid pinching or crimping
 - b. Occluded filter: may decrease or stop the flow rate
 - 1) As particulates are removed from solutions or medications, the filter may occlude
 - 2) Replace filter when this occurs
6. Patient's involved extremity: check for anything that might act as a tourniquet and impede solution flow, such as constrictive clothing, jewelry, or identification band

C. Hematoma/Ecchymosis

1. Definition
 - a. Hematoma is the bleeding underneath the skin caused by damage to a vessel
 - b. Ecchymosis or discoloration of the skin is a symptom of bleeding underneath the skin
2. Causes
 - a. Inadvertent puncture of an adjacent vessel can cause hematoma
 - b. "Double-wall" technique during insertion can cause hematoma; clinician cannulates the vein through one side of the vessel all the way through the back side of the vessel and then pulls the needle back until blood return is observed and continues with the line placement
3. Signs and symptoms
 - a. Tissue discoloration from blood infiltrating the area
 - b. Swelling as hematoma is formed
 - c. Onset immediate or slow, depending on the amount of subcutaneous tissue between the vein and epidermis
4. Risk factors
 - a. Multiple venipuncture attempts; traumatic insertion
 - b. Use of fragile veins (e.g., in the elderly)
 - c. Inappropriately placed tourniquet
 - d. Venipuncture in patients with a blood dyscrasia or in those who bruise easily
 - e. Patients taking steroids or anticoagulants
 - f. Multiple entries into a vein

- g. Attempts made into poorly visible or impalpable veins
- h. Accidental arterial puncture can cause restrictive hematoma and requires immediate attention; may be life-threatening
- 5. Interventions
 - a. Hematoma
 - 1) Remove catheter immediately and apply direct pressure to the area
 - 2) Elevate involved extremity until bleeding ceases, as appropriate
 - 3) Apply a dry, sterile dressing to the site
 - 4) Apply ice to the area to prevent hematoma enlargement
 - 5) Monitor the site for breakthrough bleeding
 - 6) Monitor the extremity for circulatory, neurological, and motor function
 - 7) Hematoma formation following attempted access of the subclavian vein may be life-threatening depending on severity
 - b. Ecchymosis
 - 1) Remove catheter and apply light pressure dressing
 - 2) Do not apply heavy pressure because it may rupture fragile vessels within the area and increase bleeding
 - 3) Area usually feels sore but is rarely painful unless a hematoma has formed
 - 4) Area appears unsightly, but this usually disappears in 1 to 2 weeks
- 6. Documentation: severe ecchymosis, hematoma with excessive bleeding, or hematoma requiring medical intervention should be documented
- 7. Preventive measures
 - a. Hematomas are not always preventable, but the severity can be minimized by the performance of venipuncture by highly skilled professionals
 - b. Venipuncture performed on fragile veins without a tourniquet
 - c. Using visualization technologies (e.g., ultrasound) to aid in vein identification and selection

D. Infiltration/Extravasation

- 1. Definition
 - a. Infiltration is the inadvertent administration of a nonvesicant solution or medication into the surrounding tissue
 - b. Extravasation is the inadvertent administration of a vesicant solution or medication into the surrounding tissue; a vesicant is a solution or medication that is capable of causing blistering, sloughing, or necrosis when it escapes into tissue
- 2. Causes
 - a. Damage to the intima of the vein
 - b. Erosion of the vessel by the catheter
 - c. Thrombus formation around the catheter causing infusion to back up and split the vein
 - d. Catheters that have migrated out of the vessel allowing infusion to fill the surrounding tissue
- 3. Signs and symptoms
 - a. Pain, swelling
 - b. Blanching, tight feeling, taut skin
 - c. Coolness of the skin temperature
 - d. Can lead to deep pitting edema and circulatory impairment
 - e. A standardized scale should be used for assessing and documenting infiltration/extravasation (see Fig. 1.1)

Grade	Clinical Criteria
0	No symptoms
1	Skin blanched Edema, <1 inch in any direction Cool to touch With or without pain
2	Skin blanched Edema 1–6 inches in any direction Cool to touch With or without pain
3	Skin blanched, translucent Gross edema >6 inches in any direction Cool to touch Mild–moderate pain Possible numbness
4	Skin blanched, translucent Skin tight, leaking Skin discolored, bruised, swollen Gross edema >6 inches in any direction Deep pitting tissue edema Circulatory impairment Moderate–severe pain Infiltration of any amount of blood products, irritant, or vesicant

FIGURE 1–1. Infiltration Scale.

4. Risk factors
 - a. Multiple manipulations of infusion delivery system
 - b. Large gauge and length of catheter
 - c. Failure to stabilize VAD adequately
 - d. Patient age, condition, acuity
 - e. Administration of irritating infusates/solutions (acid/alkaline pH, high osmolarity) via a peripheral VAD
 - f. Infusion history
 - g. Inadequate VAD insertion technique
 - h. Inadequate care and maintenance practices
 - i. Extended dwell time
5. Assessment
 - a. General
 - 1) Do not rely on alarms from EIDs for detection
 - 2) Compare device insertion site with the same area on the opposite side or extremity
 - 3) Flow rate remains unchanged even with tourniquet applied above the insertion site or digital pressure held at tip of catheter
 - 4) Blood return is not a predictor of infiltration since the catheter may be in a damaged vessel
 - 5) Teach patient and/or caregiver signs and symptoms to report and the importance of immediate reporting

- b. Short peripheral and midline catheters
 - 1) Changes in skin color, including blanching, bruising, or redness surrounding insertion site
 - 2) Edema in any direction from the insertion site
 - 3) Changes in skin temperature, including coolness or warmth
 - 4) Pain, burning, or stinging with injection or infusion
 - 5) Development of blisters
 - 6) Impaired ability to move fingers, hand, or extremity
 - 7) Numbness, tingling, paresthesia
 - 8) Fluid leakage from insertion site
 - 9) Slow capillary refill
- c. CVADs
 - 1) Fluid leakage from insertion site
 - 2) Noncoring needle dislodgment
 - 3) Pain or discomfort of any kind at the insertion site, tip location, or along the CVAD's venous pathway
- 6. Interventions
 - a. Infiltration
 - 1) Stop the infusion immediately, aspirate fluid from catheter with a small syringe and remove catheter
 - 2) Institute appropriate supportive treatments
 - a) Elevation of extremity
 - b) Thermal applications; cool or warm, moist
 - b. Extravasation
 - 1) Stop infusion immediately
 - 2) Aspirate for infused medication with a small syringe before removal
 - 3) Notify LIP and implement extravasation protocols as ordered
 - 4) Treatment depends on the type of medication and severity of the complication; may include surgical intervention
 - a) Thermal application
 - Heat or cold based on the vesicant
 - Cooling is recommended for alkylating agents, anthracyclines, antitumor antibodies, and taxanes
 - Heat is recommended for plant alkaloids, vasoconstricting agents (e.g. dopamine, dobutamine, epinephrine)
 - b) Antidotes
 - Sodium thiosulfate for alkylating agents
 - Dexrazoxane for anthracyclines
 - Hyaluronidase for plant alkaloids
 - Phentolamine for vasopressors (e.g., dopamine, epinephrine, metaraminol)
 - 5) Observe site for signs and symptoms of compartment syndrome, nerve injury, blisters, skin sloughing, tissue necrosis, functional and sensory loss
 - 6) Photograph affected area
 - a) At time of injury
 - b) 24 hours after injury
 - c) 48 hours after injury
 - d) 1 week after injury
- 7. Preventive measures
 - a. Use smallest gauge, shortest length catheter to accommodate the prescribed infusion

- b. Consider a CVAD for infusates with a pH <5 or >9, or osmolarity >600 mOsm/L, or final dextrose concentration >10%
 - c. Avoid areas of flexion and the lower extremities for catheter placement
 - d. Avoid veins in the digits, hands, and wrist because of the close network of tendons and nerves
 - e. Avoid subsequent cannulations proximal to previous sites
 - f. Stabilize catheter to prevent movement at the insertion site
 - g. Infuse irritating infusates into large peripheral veins
 - h. Ensure patency of VAD prior to infusion and assessing for brisk blood return upon aspiration
 - i. Check patency of VAD during vesicant administration by aspirating for a blood return
 - 1) IV push: every 2 to 5 mL
 - 2) Short infusion (<60 minutes): every 5 to 10 minutes
 - 3) Avoid peripheral vesicant infusions of >60 minutes in duration
 - j. Vesicants should be administered through a secondary port of a free-flowing infusion if possible to increase dilution and decrease severity of tissue exposure
 - k. Instruct patient to immediately report any pain, burning, or swelling with infusion administration
8. Documentation
- a. Patient's permanent medical record
 - 1) Date and time of infiltration/extravasation
 - 2) Catheter type and size
 - 3) Whether insertion site is new or preexisting
 - 4) Drug administered, method of administration, and estimated volume of fluid that escaped into the tissue
 - 5) Patient complaints or experience during the extravasation
 - 6) Appearance of access site
 - 7) Treatment measures taken and outcome
 - b. Unusual occurrence or sentinel event report completed according to organizational policy

E. Phlebitis

- 1. Inflammation of the endothelial cells of the vessel
 - a. Creates a rough cell wall on the vein intima to which platelets adhere
 - b. May extend up or down a large portion of the vein
- 2. Types
 - a. Mechanical phlebitis
 - 1) Catheter irritates vein intima during insertion and dwell time
 - 2) Contributing factors
 - a) Inappropriate site selection such as using areas of flexion
 - b) Inadequate vein size for the catheter gauge
 - c) Inadequate catheter securement
 - d) Traumatic insertion
 - b. Chemical phlebitis
 - 1) Occurs as a response of the vein intima to chemicals producing inflammation
 - 2) Contributing factors
 - a) Irritating medications and solutions
 - b) Medications improperly mixed or diluted

- c) Medications/solutions administered at a rapid rate
 - d) Particulate matter
 - e) Catheter material
 - f) Extended catheter dwell time
- c. Bacterial phlebitis
 - 1) Inflammation of the vein wall associated with a bacterial infection
 - 2) May predispose patient to bloodstream infection
 - 3) Contributing factors
 - a) Poor hand hygiene
 - b) Failure to check equipment for compromised integrity
 - c) Poor aseptic technique in preparing venipuncture site or infusion system
 - d) Poor catheter insertion techniques
 - e) Inadequate catheter securement
 - f) Extended catheter dwell time
 - g) Infrequent assessment and failure to identify early signs of phlebitis
- d. Postinfusion phlebitis
 - 1) Associated with inflammation of the vein that becomes evident within 48 to 96 hours of catheter removal
 - 2) Contributing factors
 - a) Poor catheter insertion technique
 - b) Debilitated patient
 - c) Poor vein condition
 - d) Hypertonic or acidic solutions
 - e) Ineffective filtration
 - f) Large-gauge catheter placed in small vessel
 - g) Inadequate VAD care and maintenance practices
- 3. Interventions
 - a. Frequent assessment of venipuncture site and adjacent area
 - 1) If phlebitis is suspected a standardized Phlebitis Scale should be used to determine severity (see Fig. 1.2)
 - 2) Determine the potential cause of the phlebitis
 - b. Discontinue infusion and remove VAD as appropriate
 - c. Notify LIP regarding the degree of phlebitis
 - d. Apply thermal compress to phlebitic area for 20 minutes, 3 to 4 times per day, with LIP's order

Grade	Clinical Criteria
0	No symptoms
1	Erythema at access site with or without pain
2	Pain at access site with erythema or edema
3	Pain at access site with erythema or edema Streak formation Palpable venous cord
4	Pain at access site with erythema and/or edema Streak formation Palpable venous cord >1 inch in length Purulent drainage

FIGURE 1-2. Phlebitis Scale.

- e. Reassess vascular access needs
- f. Replace short peripheral catheter in opposite extremity
- g. Consider CVAD if irritating fluids are probable cause
- h. Maintain statistical data on phlebitis rates
- i. Document incidence in patient's permanent medical record
 - 1) Date and time of the phlebitis
 - 2) Severity of the phlebitis based on a standardized scale
 - 3) Medication or solution being infused
 - 4) Catheter gauge and dwell time
 - 5) Intervention taken
 - 6) Patient response
- 4. Preventive measures
 - a. Use smallest gauge and shortest length catheter to accommodate the prescribed therapy
 - b. Avoid placing catheters in the areas of flexion
 - c. Collaborate with LIP regarding the need for a CVAD for infusates with as pH <5 or >9, or osmolarity >600 mOsm/L, or final dextrose concentration >10%
 - d. Perform thorough skin antisepsis before catheter insertion
 - e. Allow antiseptic to dry completely before catheter insertion
 - f. Adhere to aseptic technique with all infusion access and medication/solution administration
 - g. Stabilize VAD to minimize the movement at insertion site

F. Occlusion

- 1. Defined as partial or complete obstruction of the VAD; inability to infuse or inject fluid into a catheter, the inability to aspirate blood from a catheter
- 2. Causes
 - a. Thrombotic: fibrin or blood within or around the catheter or within an implanted port reservoir; most common
 - b. Nonthrombotic: drug precipitates, lipid deposits, or mechanical (kinks, pinch-off syndrome)
- 3. Contributing factors
 - a. Allowing the solution container to become completely empty
 - b. Inadequate or inappropriate flushing when administering medications, drawing blood, or locking a VAD
 - c. Administration of incompatible medications or solution with precipitate formation
 - d. EID malfunction
 - e. Kinked catheter or pinched administration set
- 4. Signs and symptoms
 - a. Sluggish infusion or flushing
 - b. Difficulty in or complete inability to infuse or flush
- 5. Interventions
 - a. Never flush the catheter to clear the occlusion; force can cause catheter damage or force a blood clot into the circulation
 - b. Identify cause of occlusion
 - 1) Mechanical
 - a) External: tight suture, clamped catheter, kinked tubing, obstructed filter, nonfunctioning NC

- b) Internal: catheter malposition, kinked catheter, pinch-off syndrome
- 2) Nonthrombotic: lipid buildup from 3-in-1 parenteral nutrition admixtures, drug precipitate
- 3) Thrombotic: most common; due to fibrin buildup, blood clots within or around the catheter (e.g., intraluminal occlusion or fibrin sheath/tail)
- c. Short peripheral catheter: remove catheter, and if therapy is to continue replace catheter in another vein
- d. CVADs: instill appropriate catheter-clearance agent (precipitate-clearing or declotting agent)
- 6. Preventive measures
 - a. Change solution containers when <100 mL of the solution remains
 - b. Evaluate compatibilities of solutions and medications prior to mixing or administering
 - c. Change filters on a routine basis
 - d. Ensure all clamps are open before initiating an infusion
 - e. Use proper flushing techniques
 - 1) Flush visible blood from CVAD
 - 2) Flush after blood draws
 - 3) Flush between medication/solution administration

G. Peripheral Site Infection

- 1. An infection that generally occurs at the catheter-skin entry point
- 2. Contributing factors
 - a. Poor hand hygiene
 - b. Break in aseptic technique at the time of insertion, care, or removal
 - c. Use of contaminated equipment
 - d. To-and-fro movement of the catheter secondary to VAD placement in the area of flexion or lack of or inappropriate securement
- 3. Signs and symptoms
 - a. Pain, swelling, and/or inflammation at the insertion site
 - b. Discolored tissue of surrounding area; purulent drainage may be present
- 4. Interventions
 - a. Remove catheter and culture it to determine if it is the source of infection
 - b. If there is drainage at the site, culture it prior to the removal of the catheter
 - c. Administer antibiotics if ordered
 - d. Monitor site until resolution of infection

H. Arterial or Venous Spasm

- 1. Defined as the sudden, involuntary contraction of an artery or a vein
 - a. Results in the temporary cessation of blood flow through the vessel
 - b. Arterial spasm can result in loss of blood supply to the surrounding area with tissue necrosis and gangrene
 - c. Venous spasm may result in collateral circulation causing a decrease in blood supply to the area
- 2. Contributing factors
 - a. Administration of cold solutions or medications
 - b. Administration of irritating medications or solutions
 - c. Inadvertent puncture of an artery instead of the vein during venipuncture

3. Signs and symptoms
 - a. First symptom reported by patients is usually a feeling of pain and numbness in the extremity, with cramping or pain above the catheter insertion site
 - b. Tissue damage may occur before pain is felt
 - c. Loss of pulse with localized blanching usually indicates an arterial spasm
4. Intervention
 - a. Arterial
 - 1) Remove catheter immediately
 - 2) Apply pressure to the site for approximately 5 minutes or until bleeding has stopped
 - 3) Apply dry sterile dressing
 - b. Venous
 - 1) Infusion generally not discontinued
 - 2) Identify the cause of spasm
 - a) Decrease infusion rate
 - b) Collaborate with pharmacist to determine if medication/solution can be diluted
 - c) Apply warm compresses if spasm the result of administration of cold solution

I. Nerve Injury

1. Related to direct puncture of a nerve or a compression injury due to subcutaneous hematoma pressing on the nerve, or infiltration of medication or infusate
2. Signs and symptoms
 - a. Direct puncture
 - 1) Immediate sharp pain at the venipuncture site
 - 2) Sharp shooting pain up or down arm
 - 3) Sensation of pain that changes in severity depending on needle position; "pins and needles" sensation or "electric shock" feeling
 - 4) Pain or tingling discomfort in hand or fingertips
 - b. Compression injuries
 - 1) Pain radiating up or down the arm
 - 2) Compartment syndrome due to infiltrated solution
 - a) Compartment syndrome may occur when the IV fluid or medication collects in tight spaces bound by the fascia, bone, muscle, and skin
 - b) Decreased perfusion in the area can lead to irreversible nerve damage and loss of function
 - 3) Numbness or tingling in the arm or hand; typically appears 24 to 96 hours after the venipuncture
3. Interventions
 - a. Sharp, shooting pain during venipuncture, stop the procedure immediately, remove the VAD, and notify LIP
 - b. Compression injury
 - 1) Immediately notify LIP and discontinue the infusion
 - 2) Collaborate with LIP for rapid interventions to reduce the risk of permanent injury
 - 3) Interventions may include elevation of the extremity and/or thermal compresses
 - 4) Fasciotomy may be indicated

4. Preventive measures
 - a. Choose prominent accessible veins, avoid veins on the inner surface of the wrist and forearm; avoid the lateral surface of the wrist for approximately 4 to 5 inches because of the potential for nerve damage
 - b. Use a smaller needle angle (15°) relative to vein depth; do not exceed 30° for deeper veins
 - c. Avoid probing, which may nick the vein and cause subcutaneous bleeding



III. Systemic Complications

A. Overview

1. Potential to affect all body systems
2. Usually serious, requiring immediate intervention; may be life-threatening

B. Bacteremia/Septicemia

1. Bacteremia, or bloodstream infection, is defined by the presence of microorganisms in the blood as identified by positive blood cultures. Septicemia is defined by the presence of pathogenic microorganisms or their toxins in the blood
2. Considered catheter-related when the same organisms are isolated from both the catheter surface and blood
3. Risk factors
 - a. Immunosuppression and immunodeficiency
 - b. Severe underlying chronic illness (e.g., diabetes mellitus)
 - c. Administration of multiple infusions
 - d. Extended hospitalization
 - e. Inadequate aseptic technique during infusion-related procedures
 - f. Presence of concurrent infection (e.g., urinary or respiratory tract infection)
 - g. Leukopenia
 - h. Age
 - i. Burns
4. Signs and symptoms
 - a. Initial symptoms
 - 1) Fever
 - 2) Chills
 - 3) General malaise
 - 4) Headache
 - b. Increased pulse rate and prostration
 - c. Flushed face, backache, nausea, vomiting, and hypotension are possible
 - d. Cyanosis, increased respirations, and hyperventilation occur if condition goes undetected or untreated
 - e. Vascular collapse, shock, and death can result
5. Interventions
 - a. Notify LIP
 - b. Obtain blood cultures as ordered; cultures of the cannula, blood, and par-ent-eral solution may be ordered
 - c. Remove catheter and culture catheter tip/segment using semiquantitative method if ordered
 - d. Administer antibiotics as ordered

6. Preventive measures
 - a. Perform hand hygiene prior to placement and before providing VAD-related interventions
 - b. Use MSB precautions during CVAD insertion
 - c. Choose the optimal CVAD site for placement
 - d. Use chlorhexidine for skin antisepsis prior to CVAD insertion
 - e. Disinfect NCs prior to access
 - f. Maintain aseptic technique during all infusion therapy administrations and VAD care
 - g. Change administration set and add-on devices at recommended intervals; minimize the use of add-on devices
 - h. Remove VAD when no longer needed

C. Pulmonary Embolism

1. Description
 - a. A condition that occurs when a mass of undissolved matter becomes free floating and is carried by the venous circulation to the right side of the heart, occluding a pulmonary vessel
 - b. Matter may be solid, liquid, or gaseous: may consist of bit of tissue, tumor cells, fat globules, air bubbles, clumps of bacteria, or foreign bodies
2. Signs and symptoms
 - a. Pulmonary hypertension
 - b. Possible right-sided heart failure
 - c. Dyspnea
 - d. Pleuritic pain or discomfort
 - e. Anxiety, apprehension, restlessness
 - f. Tachypnea
 - g. Tachycardia
 - h. Sweats
 - i. Cyanosis
 - j. Low-grade fever
3. Interventions
 - a. Place patient in semi-Fowler's position
 - b. Monitor vital signs
 - c. Notify LIP for orders for the following:
 - 1) Radiographic confirmation
 - 2) Oxygen therapy
 - 3) Complete blood count, partial thromboplastin time
 - 4) Anticoagulation therapy

D. Air Embolism

1. Description
 - a. Entry of a bolus of air into the vascular system
 - b. Creates an intracardiac airlock at the pulmonic valve
 - c. Prevents ejection of blood from the right side of the heart
 - d. Force of right ventricular contractions increases
 - e. Small air bubbles break loose and enter pulmonary circulation creating obstruction to forward blood flow
 - f. Tissue hypoxia results
2. Causative factors
 - a. Open port or leak in infusion system

- b. Inadvertent injection of air into a port
 - 1) Accidental disconnection of the administration set
 - 2) Solution container on EID is allowed to empty
 - 3) Failure to remove air from the system before use
 - 4) Catheter fracture
- c. Patient cannot, or fails to, perform Valsalva maneuver during insertion of, set changes on, or removal of CVADs
- d. Failure to have patient remain flat during and after CVAD removal for at least 30 minutes
- e. Failure to place occlusive dressing over catheter exit site
- f. Presence of a persistent catheter tract following CVAD removal
- 3. Signs and symptoms
 - a. Chest pain, sudden onset of dyspnea, coughing
 - b. Pain in shoulder or lower back
 - c. Cyanosis
 - d. Hypotension
 - e. Jugular venous distention
 - f. Weak pulse, tachycardia
 - g. Wheezing, tachypnea
 - h. Altered mental status; altered speech
 - i. Changes in facial appearance
 - j. Numbness; paralysis
 - k. Loud continuous churning sound heard over the precordium during auscultation
 - l. Shock with cardiac arrest if condition unrecognized or untreated
- 4. Interventions
 - a. Immediately place patient on the left side with head lower than the heart
 - b. Identify the cause of and implement actions to prevent further air from entering the circulation
 - c. Notify LIP
 - d. Assess vital signs, O₂ saturation, and cardiac rhythm
 - e. Administer oxygen
 - f. Carry out other emergency measures as necessary
- 5. Preventive measures
 - a. Use connections of luer-lock design
 - b. Trace all lines from the catheter hub to the solution container to prevent misconnections
 - c. Clamp catheter when changing administration sets/add-on devices
 - d. Place patient in a position with the VAD exit site at or below the heart level when changing administration sets or connectors or for removal of a CVAD
 - e. Ensure that administration sets and add-on devices are primed with solution prior to attaching to a VAD
 - f. Use an air-eliminating filter when appropriate
 - g. Place occlusive dressing over catheter exit site

E. Catheter Embolism

- 1. Occurs when a piece of the catheter is severed and enters the circulation
- 2. Causative factors
 - a. Defective catheter
 - b. Through-the-needle catheter is pulled backward then advanced forward, causing the catheter to be pierced or severed
 - c. An over-the-needle catheter stylet is partially withdrawn, and then reinserted

- d. Catheter rupture from forced injection
 - 1) Excessive pressure during flushing
 - 2) Use of high-power injectors (up to 300 psi) for CT scans and MRIs
- e. Result of pinch-off syndrome
- f. Accidental severing
 - 1) Patient gets tangled in the tubings
 - 2) Caregiver, clinician, or patient uses scissors near the insertion site and accidentally cuts the catheter
- 3. Signs and symptoms
 - a. May be asymptomatic
 - b. Cyanosis
 - c. Shortness of breath
 - d. Chest pain
 - e. Hypotension
 - f. Tachycardia
 - g. Increased central venous pressure
 - h. Fainting or loss of consciousness
 - i. Arrhythmias, perforation of atrium or ventricle, endocarditis or cardiac arrest if catheter migrates to the heart
 - 1) May have no symptoms if the catheter rests at the lowest point of the ventricle
 - j. Pulmonary thrombus if catheter migrates through the heart and to the lung
- 4. Interventions
 - a. Immediately notify LIP
 - b. If a peripheral catheter or a PICC breaks during removal, apply tourniquet above the insertion site and place on bedrest; monitor patient and reassure, keep the patient calm
 - c. Radiographic confirmation of the catheter fragment is necessary
 - d. Surgical removal may be necessary
 - e. Monitor patient for further distress
- 5. Preventive measures
 - a. Check catheter for product integrity prior to insertion and after removal
 - b. Educate patient regarding the activity while catheter in place
 - c. Never use scissors near a catheter and teach patients the importance of using nothing sharp around the catheter
 - d. Do not use force to flush an occluded catheter
 - e. Do not reinsert a stylet through a catheter or withdraw a catheter back through the needle introducer

F. Pulmonary Edema

- a. Overload of fluid in the circulatory system
 - 1) Causes an increase in venous pressure, with the possibility of cardiac dilation
 - 2) Heart failure, shock, and cardiac arrest can occur if unrecognized or untreated
- b. Causes
 - 1) Displaced catheter in the pulmonary artery
 - 2) Left heart failure; congestive heart failure
 - 3) Renal disease
 - 4) Cirrhosis

- c. Signs and symptoms
 - 1) Early
 - a) Anxiety, restlessness
 - b) Increasing tachycardia
 - c) Headache, possible flushing
 - d) Shortness of breath, cough becoming productive
 - e) Hypertension
 - 2) Progressive
 - a) Severe dyspnea with gurgling respirations
 - b) Jugular venous distention
 - c) Puffy eyelids, edema
 - 3) Elevated wedge pressure
 - 4) Weight gain; more than 1lb per day suggest pending pulmonary edema
- d. Interventions
 - 1) Monitor vital signs frequently
 - 2) Notify LIP
 - 3) Decrease infusion rate
 - 4) Place patient in high Fowler's position
 - 5) Administer oxygen as needed
 - 6) LIP orders may include
 - a) Morphine sulfate
 - b) Therapeutic phlebotomy
 - c) Diuretics
 - d) Vasodilators
- e. Preventive measures
 - 1) Monitor infusion and maintain flow at prescribed rate
 - 2) Be familiar with patient's cardiovascular history
 - 3) Do not "catch up" infusions, instead recalibrate
 - 4) Use EIDs that have dose-error reduction systems and anti-free flow mechanisms

G. Speed Shock

- 1. Description
 - a. Systemic reaction that occurs when a substance foreign to the body is introduced into the circulation too rapidly
 - b. Relates to the rapidity with which a medication is administered versus the volume
 - c. Can occur even when a small volume of medication is given
- 2. Contributing factors
 - a. Rapid, uncontrolled infusion of a medication
 - b. Medication administered at a rate that exceeds recommended rate
- 3. Signs and symptoms
 - a. Early
 - 1) Dizziness and syncope
 - 2) Facial flushing and headache
 - b. Progressive
 - 1) Hypotension, irregular pulse, and chest tightness
 - 2) Anaphylactic shock
- 4. Interventions
 - a. Frequent assessment during first-time medication administration
 - b. Discontinue infusion immediately when reaction noted

- c. Maintain a patent VAD
 - d. Implement emergency measures as necessary
 - e. Notify LIP for further orders
5. Preventive measures
- a. Reduce the size of the drop by using microdrip set
 - b. Monitor the infusion rate; use an EID
 - c. Dilute IV push medications if possible

H. Allergic Reaction

1. Description
 - a. A response to a medication or solution to which the patient is sensitive
 - b. Response may be immediate or delayed
 - c. Most commonly seen with antibiotic administration and blood transfusion
2. Signs and symptoms
 - a. Chills or fever with or without urticaria, erythema, or itching
 - b. Shortness of breath with or without wheezing
 - c. Anaphylactic shock
3. Interventions
 - a. Stop the infusion
 - b. Change administration set and solution container
 - c. Maintain a patent VAD
 - d. Notify LIP; orders may include administration of antihistamines, epinephrine, or cortisone
4. Preventive measures
 - a. Obtain a thorough allergy and drug history, note any cross-sensitivity
 - b. Identify risk factors: history of severe drug reactions and family history of same, when administering blood/blood components and the first dose of an intravenous medication with the risk for a severe allergic reaction/anaphylaxis
 - c. Have emergency medications readily available with first dose medication administration and for patients with ongoing risk of severe allergic reaction



IV. Complications Associated with CVADs

A. Insertion-Related Complications

1. Contributing factors
 - a. Unskilled inserter
 - b. Multiple attempts and needle passes
 - c. Failure to use visualization technologies (e.g., ultrasonography) for insertion
2. Pneumothorax
 - a. Description
 - 1) Presence of air or gas in the pleural cavity
 - 2) Occurs when the parietal or visceral pleura is breached and the pleural space exposed to positive atmospheric pressure allowing air to enter the pleural space and the lung or portion of it to collapse
 - 3) Most frequently occurs during subclavian approach, usually due to anatomical proximity of the lungs to the subclavian vein
 - b. Signs and symptoms
 - 1) Depends on size and cause

- 2) May be asymptomatic and go unrecognized until radiographic confirmation of catheter tip
 - 3) Sudden chest pain
 - 4) Shortness of breath
 - 5) Anxiety
 - c. Interventions
 - 1) If not diagnosed until radiographic confirmation of catheter tip, notify LIP
 - 2) Remove catheter and apply pressure to site
 - 3) Monitor vital signs
 - 4) Administer oxygen as ordered
 - 5) Chest tube may be inserted if necessary
 - d. Prevention: the use of visualization technologies minimizes risk of accidentally puncturing the lung
3. Hemothorax
- a. Description
 - 1) Blood in the pleural space
 - 2) Occurs when a vessel, especially an artery is punctured in the chest during central line placement, and places pressure on the lung
 - b. Signs and symptoms
 - 1) May be asymptomatic and go unrecognized until radiographic confirmation of catheter tip
 - 2) Sudden onset of pain with dyspnea during catheter insertion
 - 3) Anemia and respiratory distress if not treated quickly
 - c. Interventions
 - 1) During insertion
 - a) Remove needle and catheter
 - b) Apply pressure to the site
 - c) Monitor vital signs
 - d) Administer oxygen as ordered
 - 2) Upon radiographic confirmation of catheter tip
 - a) Notify LIP
 - b) Remove catheter and apply pressure to the site
 - c) Monitor vital signs
 - d) Administer oxygen as ordered
 - 3) Chest tube may be required to resolve complication
 - d. Prevention: the use of visualization technologies minimizes the risk of accidentally puncturing an unintended vessel
4. Hydrothorax
- a. Description
 - 1) Serous fluid accumulation in the pleural space
 - 2) Transection of the subclavian vein and placement of catheter in the thorax
 - 3) Erosion of the vein wall by the catheter, manipulation of a large dilator, or a kinked guidewire
 - 4) Occurs more often in patients with a left-sided CVAD where the catheter meets the lateral wall of the SVC at a 45° angle
 - 5) Usually delayed complication
 - b. Signs and symptoms
 - 1) Chest pain
 - 2) Dyspnea
 - 3) Murmur with a flat sound over the location of the fluid

- c. Interventions
 - 1) Remove catheter
 - 2) Monitor vital signs
 - 3) LIP may need to aspirate fluid from the pleural space
 - 4) Chest tube may be necessary
- d. Prevention: the use of visualization technologies minimizes the risk of accidentally puncturing an unintended vessel
- 5. Brachial plexus injury
 - a. Description
 - 1) Unintended puncture of or pressure on the brachial plexus
 - 2) Involves nerves near the spine that run through the neck, axilla, and into the arm, controlling the shoulder and arm; the group of nerves that pass through the cervico-axillary canal to axilla and supplies brachium, antebrahium, and hand
 - 3) Causes: multiple venipuncture attempts or a hematoma
 - 4) Can occur with internal jugular or subclavian catheterization
 - 5) Damage may be permanent
 - b. Signs and symptoms
 - 1) Tingling sensation in the fingers
 - 2) Shooting pain down extremity
 - 3) Numbness
 - 4) Weakness or loss of control in the arm, hand, or wrist or paralysis of extremity
 - c. Interventions
 - 1) Notify LIP immediately
 - 2) Administer pain medication as ordered
 - 3) Physical therapy may be required
 - d. Prevention: the use of visualization technologies minimizes the risk of accidentally puncturing any nerves
- 6. Inadvertent arterial puncture
 - a. The unintended puncture of an artery during insertion; severity of injury depends on timeliness of recognition
 - b. Signs and symptoms
 - 1) Bright red arterial blood is withdrawn from the insertion needle
 - 2) Visualization of pulsatile blood in the catheter
 - 3) Potential for hematoma formation with tracheal compression or respiratory distress if unrecognized
 - c. Interventions
 - 1) Remove VAD, and if possible apply pressure to arterial puncture site for at least 5 minutes, longer if patient has a history of bleeding or platelet disorder
 - 2) Monitor for signs of bleeding
 - 3) Assess for hematoma formation
 - 4) Monitor for difficulty in breathing secondary to tracheal compression
 - d. Prevention: use of visualization technologies minimizes the risk by visualization of the pulse in the artery
- 7. Malposition
 - a. Misplacement of the catheter tip within (intravascular) or outside (extravascular) the vascular system
 - 1) Most often occurs upon insertion
 - 2) More common with subclavian access attempts than jugular access attempts

- b. Extravascular malposition
 - 1) The catheter or introducer slips out of vein during the process of threading the catheter
 - 2) Signs and symptoms
 - a) Similar to pneumothorax when lung involved
 - b) Similar to hemothorax when blood enters the mediastinum
 - c) May cause arm, neck, or chest swelling
 - d) Inability to obtain blood or loss of blood return on placement
 - e) Hydromediastinum can result from infusing into the mediastinum around the heart and central vessels
 - 3) Interventions
 - a) Notify LIP of symptoms or radiographic report if condition not noted on insertion
 - b) Remove catheter
 - 4) Prevention: placement of the VAD using visualization technologies
- c. Intravascular malposition
 - 1) Catheter tip is not in the lower third of the SVC, but it is in another vessel
 - 2) Common misplacements include
 - a) Internal jugular
 - b) Contralateral innominate vein
 - c) Azygos vein
 - d) Right and left internal thoracic veins
 - e) Accessory hemizygous veins
 - f) Superior intercostal veins
 - g) Most common malposition for the cephalic vein is the axillary vein
 - h) RA placement: catheter must be retracted into the vena cava to prevent dysrhythmia or atrial perforation
 - 3) Signs and symptoms
 - a) Difficult infusion or aspiration of the catheter
 - b) Loss of blood return
 - c) Pain, fullness, edema in the shoulder, neck, or arm
 - d) "Waterfall" (gurgling) sound in the ear when catheter tip is in internal jugular during fluid administration or flushing
 - e) Neurological damage can occur from infusion of medications into the internal jugular vein which retrogrades into intracranial venous sinuses and tributary vein
 - 4) Interventions
 - a) Attempt to reposition catheter
 - Rapid flush technique: flush with 20 mL of 0.9% sodium chloride at 4 to 5 mL/second; will not always work with multilumen or stiff catheters
 - For displacement in the jugular vein, reposition patient in Fowler's position, attempt turning patient's head toward the insertion site; if not successful, turn patient's head toward the opposite direction and raise or lower arm
 - For displacement in the axillary vein, place the patient in contralateral position, raise head of bed
 - For displacement in the subclavian, innominate, or internal jugular vein: place patient in high Fowler's position, or elevate the head of bed to 30° or more to allow gravity to reposition catheter

- Use guidewire exchange for catheters malpositioned in the subclavian, internal jugular, or innominate vein that will not respond to previous techniques
- b) Catheter placed in the atrium must be retracted into the vena cava; exception is catheter placed for dialysis purposes
- c) Radiographic confirmation is needed to verify tip location following each attempt to reposition
- d) If catheter cannot be successfully repositioned it should be removed
- e) No external portion of a CVAD that has been in contact with the skin should be advanced into the vein
- 5) Preventive measures
 - a) Using visualization technologies decreases the risk of malposition
 - b) For PICC placement, measure the distance for the proposed insertion site to RA
 - c) Turn patient's head toward the side of insertion to create an angle between the subclavian and internal jugular veins
 - d) Manual compression of the jugular vein to avoid misdirection may be helpful
 - e) Fluoroscopy may be required for difficult placements
 - f) When placing a PICC, follow a slow and steady course when threading the catheter without using force
- 1. Local CVAD site infection
 - a. Types
 - 1) Exit site: infection at the catheter-skin junction site with or without sepsis
 - 2) Port-pocket or tunnel-tract infection
 - 3) May or may not be associated with bloodstream infection
 - 4) Skin insertion site is the most common source of pathogens and colonization for entrance into the catheter tract
 - b. Signs and symptoms
 - 1) Exit site infection
 - a) Erythema, swelling, or induration of catheter-skin junction
 - b) Tenderness or pain around site
 - c) Purulence at exit site
 - 2) Port-pocket or tunnel-tract infection
 - a) Erythema
 - b) Necrosis of skin over implanted port reservoir
 - c) Tenderness and induration
 - d) Purulent exudates from needle access site or subcutaneous port pocket
 - e) Induration in tissues overlying the catheter
 - c. Interventions
 - 1) Exit site infection
 - a) Notify LIP
 - b) Obtain culture of purulent exudates
 - c) Apply topical ointment to affected area as ordered
 - d) Apply warm, moist compresses
 - e) Initiate anti-infective therapy as ordered
 - 2) Port-pocket or tunnel-tract infection
 - a) Notify LIP
 - b) Anticipate removal of VAD
 - d. Preventive measures: same as those for bloodstream infections

2. Catheter-associated venous thrombosis
 - a. Secondary venous thrombosis related to the presence of a CVAD; includes extraluminal fibrin sheath, mural thrombosis overlying the fibrin sheath, and veno-occlusive thrombosis
 - b. Contributing factors
 - 1) Presence of chronic diseases that produce a hypercoagulable state such as cancer, diabetes, irritable bowel syndrome, and end-stage kidney failure
 - 2) Known presence of genetic coagulation abnormalities (e.g., Factor V Leiden, prothrombin mutation)
 - 3) Pregnancy or use of oral contraceptive, surgery, and immobility
 - 4) History of multiple CVADs, especially with difficult or traumatic insertion and the presence of other intravascular devices (e.g., pacemaker)
 - 5) Age extremes in young children and older adults
 - 6) Catheter material, diameter, and number of lumens
 - c. Signs and symptoms
 - 1) Pain and/or edema in the extremity, shoulder, neck, or chest
 - 2) Engorged peripheral veins on the extremity, shoulder, neck, or chest wall
 - 3) Difficulty with neck or extremity motion
 - 4) Signs or symptoms of pulmonary emboli including dyspnea, apprehension, pleuritic discomfort or pain, diaphoresis, tachycardia, and cyanosis
 - d. Interventions
 - 1) Notify LIP immediately
 - 2) Initiate emergency interventions and basic life support as needed (e.g., severe dyspnea, suspected embolus)
 - 3) Administer oxygen as needed
 - 4) Obtain radiograph studies to confirm catheter placement and presence of venous thrombosis
 - 5) Initiate anticoagulant or thrombolytic therapy as ordered
 - e. Prevention
 - 1) Ensure optimal catheter tip location in vena cava
 - 2) Use catheters with small diameter
3. Pinch-off syndrome
 - a. CVAD inserted percutaneously via the subclavian vein is compressed between the clavicle and the first rib by the subclavius muscle and costoclavicular ligament
 - 1) May cause intermittent or continuous compression
 - 2) Can result in catheter tearing, transection, and catheter embolism
 - 3) May occur from day of insertion to months postinsertion
 - b. Signs and symptoms
 - 1) Transient catheter occlusion with postural movement
 - 2) Difficulty with flushing, infusing, or aspirating
 - 3) Pain and swelling with catheter disintegration and fragmentation
 - c. Intervention: catheter removal
 - d. Prevention measure: inserting the catheter lateral to the midclavicular line
4. Dislodgement and Twiddler's syndrome
 - a. Description
 - 1) Dislodgement: displacement of a catheter or port after insertion
 - 2) Twiddler's syndrome: displacement of a port resulting from the nervous habit of a patient twisting and playing (twiddling) with the port

- b. Signs and symptoms
 - 1) Movement of the implanted port and inability to insert noncoring needle into the septum
 - 2) Catheter is retracted; longer amount of catheter is out of the insertion site
 - 3) Dacron cuff is visible or outside the insertion site
 - 4) Noticeable coiling of the catheter underneath the skin
 - 5) Potential for signs and symptoms of infiltration or extravasation
 - 6) Difficulty with aspiration or infusion
 - 7) Occlusion
 - 8) Leaking around the insertion site
 - 9) Edema, redness, or pain with infusion
- c. Interventions
 - 1) Notify LIP for treatment orders
 - 2) Educate patient before discharge to home essential for proper protection of the catheter
 - 3) Catheter pulled out
 - a) Apply sterile occlusive dressing with antiseptic ointment to insertion site
 - b) Notify LIP
 - c) Based on patient condition and prescribed therapy, a new CVAD may need to be placed
 - 4) Dislodgement suspected
 - a) Notify LIP
 - b) Radiographic studies may be ordered to confirm dislodgement
 - c) Catheter may need to be repositioned or removed
 - d) Based on patient condition and prescribed therapy, a new CVAD may need to be placed
- d. Preventive measures
 - 1) Stabilize catheter with securement device
 - 2) Utilize measures, such as looping administration sets and catheters, to prevent pulling on the catheter at skin-exit site
 - 3) Educate patient on catheter care and the dangers associated with manipulating the catheter or port
- 5. Catheter migration
 - a. Movement of a CVAD tip from its documented intended position
 - b. Causes
 - 1) Catheter tip can migrate to the internal jugular vein spontaneously
 - a) Patient coughing, vomiting, and increased intrathoracic pressure
 - b) Valsalva maneuver or forceful flush technique
 - c) Displacement by invading tumor or venous thrombosis
 - d) Change in central vasculature associated with heart disease and congestive heart failure
 - 2) Flexion, extension of the arm with PICC
 - a) Basilic and axillary catheter placement causes tip to migrate toward the heart with abduction of the arm
 - b) Cephalic catheter placement causes the tip to move away from the heart with abduction
 - 3) Inadequate securement of the VAD allowing the catheter to retract from the insertion site

- 4) Implanted ports may become unseated from the subcutaneous pocket requiring access with fluoroscopy
- c. Signs and symptoms
 - 1) No obvious signs
 - 2) Arrhythmias may indicate migration to the RA
 - 3) Possible indications include complaints of headache or pain, swelling, tenderness, or discomfort in the shoulder, arm, or neck
- d. Interventions
 - 1) Stop infusion
 - 2) Notify the LIP
 - 3) Radiographic studies performed to verify catheter tip location
 - 4) Repositioning, removal and replacement may be required
- e. Preventive measures
 - 1) Catheter migration not always preventable
 - 2) Consider arm positioning when measuring for PICC placement; if using waveform verification, have patient reposition the arm to reassure the catheter does not move into the atrium
 - 3) Avoid trauma to catheter site
 - 4) Use of a securement device
- 6. Catheter damage
 - a. Description
 - 1) Defined as unintentional break in the integrity of the catheter such as rupture, pinhole, shearing, or cut making catheter unusable
 - 2) May occur during insertion, care, and maintenance
 - 3) Implanted ports can separate at the port–catheter junction; this is considered a damaged catheter
 - b. Causes
 - 1) Use of scissors to cut dressing or tape
 - 2) Inadvertent puncture of the catheter with the use of needles
 - 3) Excessive use of force when administering medications or flush solution
 - a) Use of high-power injectors
 - b) Use of small volume syringe
 - 4) Applying a clamp directly to the catheter
 - 5) Pinch-off syndrome
 - c. Signs and symptoms
 - 1) Leaking, wet dressing
 - 2) Fluid leaking from the catheter with flush or infusion
 - 3) Swelling of the chest or arm
 - 4) Signs and symptoms of infiltration or extravasation
 - 5) Damage that is visible
 - d. Interventions
 - 1) Clamp catheter proximal to the damaged area with nonserrated clamp
 - 2) Notify LIP
 - 3) Repair catheter if repairable
 - 4) Remove catheter immediately if the catheter is not repairable; any opening in the catheter can serve as a portal of entry to bacteria or air
 - e. Preventive measures
 - 1) Use smooth, nonserrated clamp
 - 2) Avoid using sharp objects near the catheter such as scissors or needles

- 3) Use a 10-mL syringe or larger to administer medication or flush solution
- 4) Notify radiology as to whether the patient has a power injectable CVAD or not when studies are ordered with contrast
7. SVC syndrome
 - a. Obstruction of blood flow by occlusion or compression of the SVC
 - b. Causes
 - 1) Cancer: tumors invading the space and compressing the vessel such as breast, thyroid, or thymic cancer, lymphoma, and lung metastasis
 - 2) Scarring from physiologic disease: histoplasmosis, thrombophlebitis, tuberculosis, aortic aneurysm, pericarditis, and enlarged thyroid gland
 - 3) Results of a blood clot, fibrin, or both
 - c. Signs and symptoms (may be gradual or sudden)
 - 1) Progressive shortness of breath, cough, hoarseness, chest pain, and swelling of face
 - 2) Extensive edema of the upper body without edema of the lower body; referred to as short cap edema
 - 3) Sensation of skin tightness and difficulty swallowing
 - 4) Headache, red face, or cheeks that becomes cyanotic
 - 5) Red palms and mucous membranes that turn blue
 - 6) Head or ear feels "full"
 - 7) Engorged and distended jugular, temporal, and arm veins
 - 8) Dilated thoracic vessels causing a prominent vein pattern on the chest wall
 - 9) Vision changes and altered mental status related to increased intracranial pressure
 - 10) Cerebral anoxia and bronchial obstruction can progress to patient demise
 - d. Interventions—considered an emergency
 - 1) Notify LIP
 - 2) Place in semi-Fowler's position
 - 3) Provide support as the patient becomes more anxious
 - 4) Administer oxygen
 - 5) Monitor fluid volume status to minimize further edema
 - 6) Monitor cardiovascular and neurological status
 - 7) Consider alternate vascular access
 - 8) Radiographic studies to confirm diagnosis
 - 9) Relief of the blockage may include
 - a) Diuretics, glucocorticoid therapy
 - b) Anticoagulants, thrombolytics
 - c) Antianxiolytics
 - d) Bronchoscopy
 - e) Chemotherapy and radiotherapy
 - f) CVAD removal when thrombus is present
 - g) Surgery and placement of an intravascular stent
8. Cardiac tamponade
 - a. Description
 - 1) Complication caused by the accumulation of excess fluid in the pericardium compressing the heart
 - 2) Results in increased pericardial pressure, reduced venous return to the heart, and decreased cardiac output

- b. Causes
 - 1) Extravascular tip location
 - 2) CVAD migration and dislodgement
- c. Signs and symptoms
 - 1) Neck vein engorgement
 - 2) Hypotension with or without symptoms of heart failure
 - 3) Feeling of fullness within chest
 - 4) May have substantial or ill-defined pain
 - 5) Shortness of breath
 - 6) Distant (muffled) heart sounds on auscultation
 - 7) Anoxic brain injury and/or death can result if condition unrecognized or untreated
- d. Interventions
 - 1) Emergency intervention by LIP is essential
 - 2) Pericardiocentesis may be required

Part VII: Alternative Access



I. Arterial

A. Indications

- 1. Hemodynamic monitoring
 - a. Systolic, diastolic, and mean arterial pressure readings
 - b. Assessment of cardiovascular effects of vasopressor and/or vasodilator drugs during the treatment of shock
 - c. Serial or daily drawing of arterial blood for ABGs
- 2. Diagnostic
 - a. Measurement of oxygen and carbon dioxide levels
 - b. Measurement of bicarbonate blood levels

B. Assessment Relative to Therapy

- 1. Patient's condition, age, and diagnosis
- 2. Medical history
 - a. Bleeding disorders
 - b. Peripheral vascular disease
 - c. Thrombosis
 - d. Use of anticoagulants
- 3. Laboratory data
 - a. Platelet count
 - b. Prothrombin time
 - c. Partial prothrombin time
 - d. International ratio
- 4. Condition, size, and location of vessel
 - a. Pulse palpated before performing an arterial puncture
 - 1) Radial artery is considered the site of choice
 - 2) Brachial and femoral arteries also appropriate
 - b. Extremity assessed for circulation distal to site

C. Site Selection

1. Radial artery
 - a. Usually considered the site of choice
 - b. Superficial and easy to enter; location at wrist makes artery easy to stabilize for quick entry
 - c. Allen's test: used to assure adequacy of collateral circulation before use; radial and ulnar arteries located and compressed; blanching of the hand indicates successful compression, with good color return to the entire hand when releasing only the ulnar artery pressure; ulnar artery capable of supplying blood to the entire hand by collateral circulation if thrombosis occurs
 - d. Easy to apply a post-puncture pressure dressing
2. Ulnar artery
 - a. Larger, much deeper, and more difficult to stabilize than the radial artery
 - b. Should not be used if radial artery of the same arm has been used
3. Femoral artery
 - a. Largest accessible artery; easily palpated, stabilized, and entered
 - b. Difficult to maintain an intact dry dressing
 - c. Digital pressure required for post-puncture pressure
 - d. Limb- or life-threatening condition possible if post-puncture thrombosis occurs
4. Pulmonary arteries
 - a. Arteries leading away from the heart to the lungs
 - b. Access obtained by insertion of pulmonary artery catheter via subclavian vein with passage through RA and RV into the pulmonary artery, providing assessment of both right and left heart pressures

D. Equipment

1. Catheter selection
 - a. Catheter choice is critical because of potential complications associated with arterial puncture
 - b. Stainless steel needles are used for intermittent arterial blood sampling; never used for indwelling access
 - c. Radiopaque catheters are routinely used for indwelling, continuous arterial access; must be able to sustain its shape and long enough to cannulate to the artery
2. Transducers and domes
 - a. Considered a closed system along with the administration set, the continuous flush device, and the flush solution
 - b. Changed using aseptic technique and observing Standard Precautions

E. Catheter Care and Maintenance

1. Aseptic technique should be used to prevent bacteria from entering the catheter insertion site
2. Assess insertion site and extremity at least every 4 hours
3. Check flush system and patency of the catheter
4. Change hemodynamic monitoring system every 96 hours
5. Arterial catheters should not be routinely removed or replaced

F. Catheter Removal

1. Upon catheter removal, digital pressure should be applied to the site until hemostasis occurs, and/or other adjunct approaches such as hemostatic pads, patches, or powders designed to potentiate clot formation, and a sterile, dry pressure dressing applied
2. The circulatory status distal to the area of cannulation should be assessed and documented after catheter removal

G. Follow-up Care

1. Observe and monitor for potential complications
 - a. Catheter insertion site and surrounding area
 - b. Circulation of involved extremity
 - c. Delayed systemic reactions in patient

H. Complications

1. Arterial spasms with resultant loss of circulation to an extremity
2. Thrombosis with resultant loss of limb or life
3. Infection and septicemia
4. Cardiac arrhythmias when placed in the RA



II. Intraspinal (Epidural, Intrathecal, Ventricular Reservoir)

A. Overview

1. Access devices located in the epidural, intrathecal, or ventricular space
2. Used in a variety of practice settings: acute care, outpatient, and home
3. Placement of intraspinal access devices is considered a medical procedure and performed by a LIP

B. Indications

1. Medication administration
 - a. Antineoplastics
 - b. Antibiotics
 - c. Anesthesia
2. Pain management (most common use)
 - a. Opiates
 - b. Local anesthetics

C. Mechanism of Action

1. The spinal cord area is innervated by sensory fibers from a single spinal nerve called dermatomes
 - a. Medications administered must reach a certain dermatomal level to achieve the desired effect
2. Lipid solubility, protein binding, and pK_a affect outcome
 - a. Lipid-soluble drugs (e.g., fentanyl) have a faster onset of action and are cleared more rapidly in CSF
 - b. Hydrophilic drugs (e.g., morphine) decline more slowly in the CSF

- c. High protein binding results in longer duration of action
- d. Nonionized forms allow medication to diffuse across the lipophilic nerve sheath and reach the sodium channels in the nerve membrane
- e. The lower the pK_a , the faster the onset of action

D. Nursing Considerations

1. Medications administered via the intraspinal route shall be preservative-free
2. Continuous infusions administered via EID
3. Alcohol, antiseptics containing alcohol, or acetone shall not be used for site preparation or for cleaning the catheter hub due to potential for deleterious effects as a neurotoxin
4. 0.2-micron surfactant-free, particulate-retentive filter to be used
5. Microbore administration set with luer-lock design and without injection ports required
6. Catheter should be aspirated prior to medication administration to ascertain the presence or absence of spinal fluid and blood
 - a. No spinal fluid or blood should be aspirated from an epidural catheter
7. Monitor and document blood pressure, respiratory rate, depth of respirations, level of consciousness, and sedation level
8. Naloxone hydrochloride (Narcan) must be readily available
9. Intraspinal access devices and administration sets are identified and labeled as a specialized administration system and differentiated from other infusion administration and access systems
10. The patient is assessed for therapeutic response to therapy; report ineffective pain management to LIP, may indicate improperly positioned catheter or need to readjust medication dosage
11. The patient is monitored for systemic complications, including paresthesia, pruritus, nausea, vomiting, urinary retention, respiratory depression, respiratory arrest, and hypotension
12. The patient is assessed for catheter-related complications, including infection, dislodgment, and leaking

E. Types of Intraspinal Access

1. Epidural
 - a. Mechanism of action
 - 1) Epidural space is the area surrounding the spinal cord and its coverings
 - 2) Epidural analgesia
 - a) Narcotic administered adjacent to the spinal cord
 - b) Narcotics diffused through a fatty or lipid membrane called the dura, with the rate of diffusion depending on the solubility of narcotic in the lipids
 - Lipid solubility is a primary determinant of intrinsic anesthetic potency, whereas protein binding determines the duration of anesthetic activity
 - The more lipid-soluble the narcotic, the faster its passage through the lipid membrane to relieve pain
 - c) Binds directly with opioid receptors to block transmission of pain
 - 3) Dose of narcotic required to achieve analgesia is approximately one-tenth of intravenous dose

- b. Medication administration
 - 1) Opioids and anesthetic medications are most frequently administered
 - a) May be administered continuously, as a bolus injection, or intermittently
 - b) Patient-controlled epidural analgesia may be used
 - 2) Injected into epidural space, depending on where pain management is desired
 - a) Lumbar region most frequently used: L₁, L₂, L₃, L₄, and L₅ interspaces most commonly used
 - b) Thoracic region may be used
- c. Types of catheters
 - 1) Specially designed catheter that is threaded through an epidural needle inserted between the spinous processes and through the ligaments into the epidural space
 - 2) Temporary catheter is made of nylon or Teflon
 - a) Used for short-term therapy, most commonly postoperative pain management
 - b) Three different long-term systems are available
 - Tunneled catheter
 - Tunneled subcutaneously from the epidural space to an abdominal exit site
 - Connected to an injection cap and a 0.2-micron filter with an extension set through which medication can be administered intermittently or continuously
 - Used as a temporary or permanent catheter
 - Total internal system
 - Catheter connected to a reservoir placed in the abdomen
 - Slow and continuous administration of medication provided
 - Placement is permanent and usually for long-term pain management
 - Catheter attached to a portal chamber
 - Placed beneath the skin over a bony surface and anchored to muscle tissue; tunneled subcutaneously and then threaded into the epidural space at the desired level, usually L₁ or L₂
 - Inserted between vertebrae joints through ligamentum flavum
 - Accessed with a noncoring needle
 - Permanently placed and usually used for long-term pain management
- d. Epidural anesthesia
 - 1) Anesthetic agents
 - a) Low anesthetic potency and short duration of action: procaine and chlorprocaine
 - b) Intermediate anesthetic potency and duration of action: lidocaine, mepivacaine, and prilocaine
 - c) High anesthetic potency and prolonged duration of action: tetracaine, bupivacaine, and etidocaine
 - 2) Factors influencing adequacy of epidural blockade
 - a) Dose, volume, and concentration of the agent
 - b) Addition of vasoconstrictor to the local anesthetic solution
 - c) Patient position
 - d) Patient age, height, and clinical status

- 3) Clinical uses
 - a) Epidural block in surgery
 - Blocks sensory and motor responses to abdomen, vaginal and perineal areas, kidney, bladder, and lower limbs
 - Essential to monitor heart rate, respiratory status, arterial pressure, and ECG
 - b) Epidural block in obstetrics
 - Essential to monitor fetus
 - Monitoring of heart rate, arterial pressure, ECG, and breathing is necessary
- e. Epidural analgesia
 - 1) Analgesia agents
 - a) Morphine: most hydrophilic agent, with longest average onset time (35 minutes), and least lipophilic agent, with longest duration of action (22 hours)
 - b) Methadone: most lipophilic agent, with shortest onset time (17 minutes), and shortest duration time (7 hours)
 - c) Hydromorphone: intermediate lipophilicity, with intermediate onset time (23 minutes), and duration (14 hours)
 - d) Fentanyl: extremely lipophilic, inducing sensory analgesia within 10 minutes, with a duration of 4 to 6 hours
2. Intrathecal
 - a. Mechanism of action
 - 1) Medications administered directly into the spinal cord
 - a) With this route, narcotics bypass the lipid membrane (dura)
 - b) Results in reduced dosage requirement for analgesia and increased interval between dosages
 - 2) Dose of narcotic approximately one tenth of epidural dose
 - 3) May be used for acute, short- or long-term pain management
 - b. Medication administration
 - 1) Method of administration same as that for epidural
 - 2) Indications
 - a) Chemotherapy
 - b) Chronic pain syndrome
 - c) Acute pain management
 - d) Antibiotic therapy
 - e) Anesthesia
 - c. Types of catheters
 - 1) Specially designed catheter that is threaded through the epidural space until the dura mater is punctured as evidenced by the aspiration of spinal fluid
 - 2) Short-term catheter made of nylon or Teflon
 - 3) Long-term systems
 - a) Implantable pump
 - b) External pump
3. Intraventricular
 - a. Ventricular reservoir
 - 1) A receptacle attached to a catheter surgically placed in the lateral ventricle of the brain with the catheter threaded into the spinal space
 - 2) Access provided to the brain or the CSF

- b. Mechanism of action
 - 1) Provides direct access to ventricular CSF
 - 2) Used to consistently and predictably deliver medications directly into the subarachnoid space and CSF
 - 3) Allows for samples of CSF to be withdrawn for pathological examination and permits the measurement of CSF pressure
- c. Medication administration
 - 1) Most often used for antineoplastic agents and pain medication
 - 2) Access obtained by penetrating the reservoir dome with a 25-gauge or smaller needle
 - 3) CSF may be withdrawn or other fluid may be injected into the reservoir
 - 4) Gentle pumping of the reservoir distributes the medication into the CSF
 - 5) Strict aseptic technique is required when accessing the reservoir
 - 6) Medication and withdrawal of CSF is most often done by LIP
- d. Advantages
 - 1) Allows immediate access to CSF and ventricles
 - 2) Eliminates repeated lumbar punctures
 - 3) Available for use with a wide range of drugs
 - 4) Permits better drug distribution
 - 5) Allows caregiver to be taught the use of the system
- e. Disadvantages
 - 1) Infection is the most common complication
 - 2) Aseptic technique is required for accessing
 - 3) Malfunction is caused by clogging
 - 4) Possible misplacement as a result of slippage of catheter

F. Complications of Intraspinal Therapy

- 1. Catheter/pump complications
 - a. Neurologic injury
 - 1) Needle introduction into the spinal cord or nerves
 - 2) Spinal cord ischemia
 - 3) Bacterial contamination of subarachnoid space
 - b. Spinal hematoma
 - 1) True medical emergency
 - 2) Occurs more frequently in the epidural space due to prominent venous plexus
 - 3) Collection of blood within the epidural space that can ultimately lead to spinal cord compression if not detected early
 - 4) The use of anticoagulants along with intraspinal infusion must be carefully considered
 - a) Low molecular weight heparin should be held for 12 hours prior to beginning an intraspinal infusion and not restarted for 2 hours post-removal of the device
 - b) For other anticoagulants, the recommendation is that the INR be equal to or <4 before initiating intraspinal infusions
 - c. Abscess
 - 1) True medical emergency
 - 2) Early identification and intervention important in preventing long-term neurological damage
 - 3) Spinal cord compression may occur which can progress to paralysis

- d. Catheter migration
 - 1) Migration may occur into or out of the intended site
 - 2) Patient may experience a decrease in pain control (intrathecal to epidural space)
 - 3) Patient may experience an increase in medication side effects (epidural to intrathecal space)
- 2. Medication side effects
 - a. Pruritus
 - 1) Result of allergic-type reaction
 - 2) Caused by the stimulation of histamine release secondary to the medication
 - b. Nausea and vomiting
 - c. Respiratory depression
 - 1) Risk factors include high doses, use of concurrent adjuvant medications, or overdosage in opiate-naïve patients
 - 2) Assess patient's responses to therapy at established intervals
 - d. Urinary retention
 - 1) Common side effect
 - 2) Due to opioid's inhibition of the parasympathetic nervous system of the bladder
 - 3) Effect is dose-dependent
 - 4) Monitor intake and output closely
 - 5) Some patients may require urinary catheterization
 - e. Hypotension
 - 1) Occurs more frequently in epidural analgesia than in systemic analgesia
 - 2) Monitor vital signs closely
 - f. Constipation
 - 1) Less common compared with oral or IV administration
 - 2) Patients may require a bowel program to help minimize effects
 - g. Sedation and confusion
 - 1) Patients need to be monitored for level of consciousness and sedation

G. Termination of Therapy

1. Catheters should not be removed if any resistance or difficulty is encountered; notify LIP



III. Intraosseous Access

A. An Infusion Administered Directly into Bone Marrow

B. Performed as an emergency short-term procedure when vascular access by the intravenous route cannot be achieved

1. Treatment and resuscitation of patients experiencing shock, venous collapse, or difficult vascular access
2. Effective route for fluid resuscitation; bolus, drug, and blood product administration; and lab evaluation

C. Equipment

1. Needles
 - a. Disposable needle specifically designed for intraosseous use are recommended
 - b. Spinal and standard bone marrow needles may also be used
 - c. Needle gauge should be 16 to 18 gauge
 - d. Devices with a stylet or trocar are preferred to prevent bone marrow from occluding the needle
 - e. Needle must be able to stand without support once the stylet is removed and must facilitate aspiration of blood and marrow
 - f. Needles with short shafts prevent dislodgment
2. Three categories of IO devices
 - a. Manual
 - b. Impact-driven
 - c. Powered drill

D. Site selection

1. Adults
 - a. FDA cleared sites include the proximal tibia, distal tibia, proximal humerus, and sternum
2. Infants and small children
 - a. Proximal and distal tibia, most frequently used
 - b. Size of the pediatric patient should be considered in relation to needle size
3. Contraindications for placement
 - a. Bone fractures of the targeted bone
 - b. Previous orthopedic procedures (prosthetic limb/joint)
 - c. Pre-existing medical condition involving the extremity
 - d. Infection near or at intended insertion site
 - e. IO within the past 48 hours in targeted bone

E. Clinical Considerations

1. Intended for short-term use only
2. Should not be left in place longer than 24 hours

F. Insertion

1. Aseptic technique required
2. Consider use of 2% preservative-free lidocaine into IO space in alert patients
3. Proper placement confirmed by the assessment of needle position and rapid flushing with 5 to 10 mL of 0.9% sodium chloride
 - a. Needle should flush without resistance
 - b. Flush is required in order to displace thick fibrin mesh
4. Only one attempt should be made to each bone
 - a. Multiple attempts on a single bone can lead to infiltration/extravasation
5. Stabilization with tape, roller gauze, or engineered stabilization device to prevent dislodgment or rocking

G. Discontinuation of Infusion

1. Site inspected and dressing changed daily until no drainage observed

H. Complications

1. Improper needle placement
2. Infection (osteomyelitis)
3. Embolus formation caused by fat and bony fragments
4. Bone fractures
5. Compartment syndrome
6. Extravasation



IV. Subcutaneous Tissue Access

A. Types of Fluids Administered

1. Medications such as opioids, insulin, terbutaline, and deferoxamine
2. Isotonic fluids for the treatment of short-term dehydration
3. Hyaluronidase may be used to increase absorption and dispersion of subcutaneously administered medications/fluids

B. Advantages

1. Cost-effective
2. Avoids need for VAD placement
3. Easy to initiate in all healthcare settings
4. Low risk for complications

C. Disadvantages

1. Volume limitations; not for use in patients requiring rapid, large volume fluid replacement
 - a. Optimal tolerated infusion rate unknown
 - 1) Medication administration rates of 3 to 5 mL/hour
 - 2) Fluid administration rates of 1,500 mL over 24 hours
2. Contraindications: patients with bleeding disorders and patients with limited subcutaneous tissue (e.g., emaciated, edematous)

D. Initiation

1. Site selection
 - a. Upper arm
 - b. Subclavicular chest wall
 - c. Abdomen
 - d. Upper back
 - e. Legs
2. Device selection
 - a. Use small gauge (25 to 27 gauge) device
 - 1) Stainless steel-winged needles
 - 2) Over-the-needle catheters
 - 3) Specially designed subcutaneous device sets
 - 4) Nonmetal subcutaneous devices are preferable, offering extended dwell time and decreased healthcare provider risk of needlestick injury

3. Site preparation
 - a. Use appropriate skin antiseptic (chlorhexidine, alcohol, povidone-iodine)
4. Placement and routine site rotation
 - a. When using stainless steel-winged needles or over-the-needle catheters, insert at 30 to 45° angle depending on the thickness of subcutaneous tissue
 - b. Aspirate to ascertain the absence of blood prior to use

E. Care and Maintenance

1. Rotate sites based on assessment and integrity of site
 - a. With medication administration, rotate every 2 to 7 days
 - b. With fluid administration, rotate every 24 to 48 hours or after 1.5 to 2.0 L of infused fluid
2. Monitor sites and rotate if the following present
 - a. Erythema
 - b. Swelling
 - c. Leaking of fluid
 - d. Bruising
 - e. Burning/pain at site

BIBLIOGRAPHY

- Abdelkefi, A., Achour, W., Ben Othman, T., Ladeb, S., Torjman, L., Lakhal, A., ... Ben Abdeladhim, A. (2007). Use of heparin-coated central venous lines to prevent catheter-related bloodstream infection. *Journal of Supportive Oncology*, 5(6), 273–278.
- Akl, E. A., Muti, P., & Schünemann, H. J. (2008). Anticoagulation in patients with cancer: An overview of reviews. *Polskie Archiwum Medycyny Wewnętrznej*, 118(4), 183–193.
- Bhutta, A., Gilliam, C., Honeycutt, M., Schexnayder, S., Green, J., Moss, M., & Anand, K. J. (2007). Reduction of bloodstream infections associated with catheters in paediatric intensive care unit: Stepwise approach. *British Medical Journal*, 334(7589), 362–365. doi: 10.1136/bmj.39064.457025.DE
- Bishop, L., Dougherty, L., Bodenham, A., Mansi, J., Crowe, P., Kibbler, C., ... Treleaven, J. (2007). Guidelines on the insertion and management of central venous access devices in adults. *International Journal of Laboratory Haematology*, 29(4), 261–278. doi: 10.1111/j.1751-553X.2007.00931.x
- Breschan, C., Platzer, M., Jost, R., Schaumberger, F., Stettner, H., & Likar, R. (2007). Comparison of catheter-related infection and tip colonization between internal jugular and subclavian central venous catheters in surgical neonates. *Anesthesiology*, 107(6), 946–953. doi: 10.1097/01.anes.0000291443.78166.98
- Bullock-Corkhill, M. (2010). Central venous access devices: Access and insertion. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 480–494). St. Louis, MO: Saunders/Elsevier.
- Centers for Disease Control and Prevention. (2012). Central-line associated bloodstream infection (CLABSI) event. Retrieved from www.cdc.gov/nhsn/PDFs/pscManual/4PSC_CLABSCurrent.pdf
- Day, M. W. (2011). Intraosseous devices for intravascular access in adult trauma patients. *Critical Care Nurse*, 31(2), 76–89. doi: 10.4037/ccn2011615
- Erasmus, V., Daha, T. J., Brug, H., Richardus, J. H., Behrendt, M. D., Vos, M. C., & van Beeck, E. F. (2010). Systematic review of studies on compliance with hand hygiene guidelines in hospital care. *Infection Control Hospital Epidemiology*, 31(3), 283–294. doi: 10.1086/650451
- Froehlich, C. D., Rigby, M. R., Rosenberg, E. S., Li, R., Roerig, P. L., Easley, K. A., & Stockwell, J. A. (2009). Ultrasound-guided central venous catheter placement decreases complications and decreases placement attempts compared with the landmark technique in patients in a pediatric intensive care unit. *Critical Care Medicine*, 37(3), 1090–1096. doi: 10.1097/CCM.0b013e31819b570e
- Galpern, D., Guerrero, A., Tu, A., Fahoum, B., & Wise, L. (2008). Effectiveness of a central line bundle campaign on line-associated infections in the intensive care unit. *Surgery*, 144(4), 492–495. doi: 10.1016/j.surg.2008.06.004
- Gorski, L., Perucca, R., & Hunter, M. (2010). Central venous access devices: Care, maintenance, and potential complications. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 495–515). St. Louis, MO: Saunders/Elsevier.

- Hadaway, L. (2010). Anatomy and physiology related to infusion therapy. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 139–177). St Louis, MO: Saunders/Elsevier.
- Hadaway, L. (2010). Infusion therapy equipment. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 391–436). St Louis, MO: Saunders/Elsevier.
- Infusion Nurses Society. (2010). Recommendations for the use of intraosseous vascular access for emergent and nonemergent situations in various health care settings: A consensus paper. *Journal of Infusion Nursing*, 33(6), 346–351.
- Infusion Nurses Society. (2011a). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S1–S110.
- Infusion Nurses Society. (2011b). *Policies and Procedures for Infusion Nursing* (4th ed.). Norwood, MA: Infusion Nurses Society.
- Infusion Nurses Society. (2012). INS position paper: Recommendations for frequency of assessment of the short peripheral catheter site. *Journal of Infusion Nursing*, 35(5), 290–292.
- Krein, S. L., Hofer, T. P., Kowalski, C. P., Olmsted, R. N., Kauffman, C. A., Forman, J. H., ... Saint, S. (2007). Use of central venous catheter-related bloodstream infection prevention practices by US hospitals. *Mayo Clinic Proceedings*, 82(6), 672–678. doi: 10.4065/82.6.672
- Kusminsky, R. (2007). Complications of central venous catheterization. *Journal of the American College of Surgery*, 204(4), 681–696. doi: 10.1016/j.jamcollsurg.2007.01.039
- Lamperti, M., Caldiroli, D., Cortellazzi, P., Vailati, D., Pedicelli, A., Tosi, F., ... Pietrini, D. (2008). Safety and efficacy of ultrasound assistance during internal jugular vein cannulation in neurosurgical infants. *Intensive Care Medicine*, 34(11), 2100–2105. doi: 10.1007/s00134-008-1210-9
- Lee, R. (2012). Intra-abdominal hypertension and abdominal compartment syndrome: A comprehensive overview. *Critical Care Nurse*, 32(1), 19–32. doi: 10.4037/ccn2012662
- Lowther, A. (2011). Intraosseous access and adults in the emergency department. *Nursing Standard*, 25(48), 35–38.
- Marshall, J., Leone, C., Jones, M., Nihill, D., Fraser, V. J., & Warren, D. K. (2007). Catheter-associated bloodstream infections in general medical patients outside the intensive care unit: A surveillance study. *Infection Control Hospital Epidemiology*, 28(8), 905–909. doi: 10.1086/519206
- McCance, K., & Huether, S. (2009). *Pathophysiology: The biologic basis for disease in adults and children* (6th ed.). Maryland Heights, MO: Mosby/Elsevier.
- McKee, C., Berkowitz, I., Cosgrove, S. E., Bradley, K., Beers, C., Perl, T. M., ... & Miller, M. R. (2008). Reduction of catheter-associated bloodstream infections in pediatric patients: Experimentation and reality. *Pediatric Critical Care Medicine*, 9(1), 40–46. doi: 10.1097/01.PCC.0000299821.46193.A3
- Munoz-Price, L. S., Hota, B., Stemer, A., & Weinstein, R. A. (2009). Prevention of bloodstream infections by use of daily chlorhexidine baths for patients at a long-term acute care hospital. *Infection Control Hospital Epidemiology*, 30(11), 1031–1035. doi: 10.1086/644751
- O'Grady, N. P., Alexander, M., Burns, L. A., Dellinger, E. P., Garland, J., Heard, S. O., ... Healthcare Infection Control Practices Advisory Committee. (2011). Guidelines for the prevention of intravascular catheter-related infections. *American Journal of Infection Control*, 39(4 Supplement 1): S1–S34. doi: 10.1016/j.ajic.2011.01.003
- Parienti, J. J., Thirion, M., Mégarbane, B., Souweine, B., Ouchikhe, A., Polito, A., ... Members of the Cathedia Study Group. (2008). Femoral vs jugular venous catheterization and risk of nosocomial events in adults requiring acute renal replacement therapy: A randomized controlled trial. *Journal of the American Medical Association*, 299(20), 2413–2422. doi: 10.1001/jama.299.20.2413
- Parker, M., & Henderson K. (2010). Alternative infusion access devices. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 516–524). St Louis, MO: Saunders/Elsevier.
- Perucca, R. (2010). Peripheral venous access devices. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 456–479). St Louis, MO: Saunders/Elsevier.
- Phillips, L. D. (2010). *Manual of I.V. therapeutics: Evidence-based practice for infusion therapy* (5th ed.). Philadelphia, PA: F.A. Davis Co.
- Piorkowski, C., Sih, H., Sommer, P., Miller, S. P., Gaspar, T., Teplitsky, L., & Hindricks, G. (2009). First in human validation of impedance-based catheter tip-to-tissue contact assessment in the left atrium. *Journal of Cardiovascular Electrophysiology*, 20(12), 1366–1373. doi: 10.1111/j.1540-8167.2009.01552.x
- Polovich, M., Whitfore, J., & Olsen, M. (2009). *Chemotherapy and biotherapy guidelines and recommendations for practice* (3rd ed.). Pittsburgh, PA: Oncology Nursing Society.
- Pronovost, P. J., Goeschel, C. A., Colantuoni, E., Watson, S., Lubomski, L. H., Berenholtz, S. M., ... Needham, D. (2010). Sustaining reductions in catheter related bloodstream infections in Michigan intensive care units: Observational study. *British Medical Journal*, 340, c309. doi: 10.1136/bmj.c309
- Ruschulte, H., Franke, M., Gastmeier, P., Zenz, S., Mahr, K. H., Buchholz, S., ... Piepenbrock, S. (2009). Prevention of central venous catheter related infections with chlorhexidine gluconate impregnated wound dressings: A randomized controlled trial. *Annals of Hematology*, 88(3), 267–272. doi: 10.1007/s00277-008-0568-7

- Schweickert, W. D., Herlitz, J., Pohlman, A. S., Gehlbach, B. K., Hall, J. B., & Kress, J. P. (2009). A randomized, controlled trial evaluating postinsertion neck ultrasound in peripherally inserted central catheter procedures. *Critical Care Medicine*, 37(4), 1217–1221. doi: 10.1097/CCM.0b013e31819cee7f
- Shapey, I. M., Foster, M. A., Whitehouse, T., Jumaa, P., & Bion, J. F. (2009). Central venous catheter-related bloodstream infections: Improving post-insertion catheter care. *Journal of Hospital Infection*, 71(2), 117–122. doi: 10.1016/j.jhin.2008.09.016
- Soothill, J. S., Bravery, K., Ho, A., Macqueen, S., Collins, J., & Lock, P. (2009). A fall in bloodstream infections followed a change to 2% chlorhexidine in 70% isopropanol for catheter connection antisepsis: A pediatric single center before/after study on a hemopoietic stem cell transplant ward. *American Journal of Infection Control*, 37(8), 626–630. doi: 10.1016/j.ajic.2009.03.014
- Timsit, J. F., Schwebel, C., Bouadma, L., Geffroy, A., Garrouste-Orgeas, M., Pease, S., ... Dressing Study Group. (2009). Chlorhexidine-impregnated sponges and less frequent dressing changes for prevention of catheter-related infections in critically ill adults: A randomized controlled trial. *Journal of the American Medical Association*, 301(12), 1231–1241. doi: 10.1001/jama.2009.376
- Vizcarra, C., & Clum, S. (2010). Intraosseous route as alternative access for infusion therapy. *Journal of Infusion Nursing*, 33(3), 162–173. doi: 10.1097/NAN.0b013e3181d9c7cf
- Webster, J., Osborne, S., Rickard, C., & Hall, J. (2010). Clinically-indicated replacement versus routine replacement of peripheral venous catheters. *Cochrane Database Syst Rev*, (3):CD007798. doi: 10.1002/14651858.CD007798.pub2
- Weinstein, S. M. (2007). *Plumer's principles & practice of intravenous therapy* (8th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.
- World Health Organization. (2009). *WHO guidelines on hand hygiene in health care*. Geneva, Switzerland: World Health Organization.
- Yeung, C. W., Cheung, W. W., Leung, A. Y., & Kwong, Y. L. (2010). Spontaneous central venous catheter fracture: Relevance of the pinch-off sign. *Journal of Hospital Medicine*, 5(4), E33. doi: 10.1002/jhm.657

Fluid and Electrolyte Balance

Lynn Phillips, MSN, RN, CRNI®



I. Body Composition and Regulation of Body Fluids

A. Body Fluid Function and Distribution

1. Water is the largest single constituent of the body
 - a. Accounts for approximately 60% of the body weight for an adult and 80% for full-term infants
 - b. Adult body weight is attained by puberty
 - 1) Increased fat stores are found in females; females have less fluid content than do males
 - 2) Fat tissue contains little water and increased body fat content generally comes with aging, accompanied by a decrease in fluid volumes
2. Fluid function
 - a. Maintains blood volume
 - b. Regulates body temperature
 - c. Transports material to and from cells
 - d. Serves as an aqueous medium for cellular metabolism
 - e. Assists digestion of food through hydrolysis
 - f. Acts as a solvent in which solutes are available for cell function
 - g. Serves as a medium for the excretion of wastes
3. Fluids are normally lost through various routes
 - a. Kidneys, as urine
 - b. Skin, as sweat
 - c. Lungs, as water vapor
 - d. Gastrointestinal tract, as vomitus and diarrhea
4. Fluid distribution
 - a. There are two major fluid compartments: intracellular and extracellular
 - 1) Infants have relatively more extracellular fluid (ECF) than do adults
 - 2) Rapid changes occur during the first 6 months of life
 - 3) By age 3 years, intracellular fluid (ICF) decreases to approximately 36%
 - 4) By puberty, the percentage approximates that of an adult

- b. ICF
 - 1) Fluid within the cells
 - 2) It constitutes the largest portion of adult total body weight (TBW) at 40% (approximately two thirds); equivalent to approximately 23 L in a 70-kg adult
- c. ECF
 - 1) Fluids located outside the cells, with a volume of approximately 12 L in a 70-kg adult
 - 2) The volume of ECF is approximately 5 to 6 L in an average adult
 - 3) It is further divided into interstitial and intravascular fluids
 - a) Interstitial fluid is the fluid located between cells and accounts for 15% of the TBW
 - b) Intravascular fluid is located in arteries, veins, and capillaries and accounts for 5% of the TBW
- d. Transcellular fluid
 - 1) Includes lymph, gastrointestinal secretions, cerebrospinal fluid, sweat, ocular fluids, and pleural, synovial, and pericardial fluids
- 5. Fluid transportation
 - a. Osmosis
 - 1) A passive transport that allows the movement of water freely through the semipermeable membrane
 - 2) The fluid moves in relation to the concentration of the solutes from low solute concentration to higher solute concentration
 - b. Diffusion
 - 1) A form of passive transport; it is the random movement of molecules and ions from an area of higher concentration to an area of lower concentration
 - 2) Several factors influence diffusion: membrane permeability, size, and number of diffusing molecules or ions, and differences in electrical charges and temperature
 - c. Filtration
 - 1) Passive transport of solutes and water together through selectively permeable membranes from higher pressure to an area of lower pressure
 - 2) Involves movement of solutes and water in relation to hydrostatic pressure
 - d. Active transport
 - 1) Requires energy to move the molecules or ions against osmotic pressure to an area of higher concentration
 - 2) Energy source for primary active transport is adenosine triphosphate (ATP)
 - e. Osmolarity versus osmolality
 - 1) Osmolarity is a measure of solute concentration
 - a) The concentration of a solution in terms of milliosmoles per liter of solution
 - b) Used in referring to solutions outside of the body
 - 2) Osmolality is the number of milliosmoles per kilogram of a solution
 - a) Used to describe fluids inside the body
 - b) 1 L of water weighs 1 kg
 - f. Tonicity or osmolarity of infusion solutions
 - 1) Isotonic solutions have the same osmolarity as normal body fluids; 250–375 mOsm/L

- 2) Hypotonic solutions contain less salt than intracellular space; osmolality below 250 mOsm/L
- 3) Hypertonic solutions cause water from within a cell to move to the ECF compartment; osmolality above 375 mOsm/L

B. Homeostatic Mechanisms

1. Overview
 - a. Internal chemical balance is necessary for normal bodily function
 - b. Several organs are responsible for ensuring balance (homeostasis)
2. Renal system
 - a. Kidneys act as major regulators of the body's water balance
 - b. Body's water balance is controlled by urine output
 - c. Electrolytes are regulated through retention or excretion of urine
 - d. Acid-base balance is maintained through excretion of noncarbonic acid and reabsorption of bicarbonate ions
 - e. Functions in the excretion of metabolic wastes and toxic chemicals
3. Cardiac system
 - a. Heart and blood vessels are responsible for circulating the blood through the kidneys, enabling urine production
 - b. Fluid regulation is assisted by the cardiovascular system through fluid volume, pressure sensors, and atrial natriuretic factor
4. Respiratory system
 - a. Lungs remove 300 to 500 mL of water through exhalation (insensible loss)
 - b. Assists in the acid-base balance maintenance through regulation of hydrogen ions
5. Endocrine system
 - a. Regulates the chemical reactions related to metabolism, growth, and reproduction
 - b. Endocrine glands that control these reactions include the pituitary, adrenal, parathyroid, and thyroid
 - c. Pituitary gland
 - 1) Signals are received by hypothalamus from the nervous system, and electrolytes are transmitted to the pituitary
 - 2) Antidiuretic hormone (ADH) is secreted by the hypothalamus and stored in the posterior pituitary, and is important for regulating renal water excretion and conservation
 - d. Adrenal gland
 - 1) Comprised of two components: adrenal cortex and adrenal medulla
 - 2) Of the two components, adrenal cortex (outside layer of the adrenal gland) is more influential in fluid and electrolyte balance
 - 3) Aldosterone, a mineralocorticoid, is secreted by the adrenal cortex
 - a) It causes potassium excretion
 - b) It causes fluid volume restoration through sodium retention
 - 4) Cortisol also influences potassium excretion and sodium and fluid retention
 - e. Parathyroid gland
 - 1) The production of parathyroid hormone affecting the regulation of calcium and phosphate is largely attributable to the effect on bone resorption
 - 2) Increased parathyroid levels result in an increased calcium level and decreased phosphate level; referred to as an inverse proportional relationship
 - 3) Exerts opposite effect with decreased hormone level

- f. Thyroid gland
 - 1) Secretes calcitonin to regulate calcium levels
 - 2) Increased calcitonin levels lead to decreased calcium concentration



II. Patient Assessment

A. Patient History

1. Disease/injury status
 - a. Renal, cardiac, respiratory, and endocrine system diseases
 - b. Chronic alcoholism
 - c. Cancer
 - d. Massive trauma, including burns and crushing injuries
2. Medications
 - a. Diuretics
 - 1) Fluid and electrolyte depletion
 - 2) Possible electrolyte excess (dependent on the type of diuretic)
 - b. Laxatives may lead to potassium deficits
 - c. Corticosteroids
 - 1) Possible fluid and electrolyte retention
 - 2) Potassium deficit
 - 3) Respiratory and metabolic alkalosis
 - d. Inappropriate use of intravenous solutions
 - 1) Excessive use of sodium-containing solutions can result in fluid volume excess (FVE) and hypernatremia
 - 2) Administration of electrolyte-free intravenous solutions can lead to electrolyte deficits
 - 3) Use of electrolyte-containing fluids could lead to excesses, depending on the content
3. Fluid status
 - a. Output exceeding intake may create fluid volume deficits (FVDs) or electrolyte imbalances
 - b. Abnormal fluid loss through vomitus, gastrointestinal suctioning, fistulas, profuse perspiration, or diarrhea may result in imbalances
 - c. Patient's activity and location of activity just before assessment can reveal if imbalance is related to activity level or excessive environmental temperature
4. Age
 - a. Takes longer and is more difficult for the elderly to regain homeostasis
 - b. Increased risk of FVD with aging
 - 1) Reduction in total body fluid
 - 2) Diminished renal function
 - 3) Increased difficulty for respiratory system to maintain a normal pH
 - 4) Decreased skin turgor makes it more difficult to determine the fluid status
 - 5) Poor intake or excessive fluid losses may occur because of confusion, decreased thirst threshold, inability to obtain fluids, and diuretic/laxative use (the most common problem is hypernatremia)
 - 6) Osteoporosis is related to calcium deficits

- c. The risks of fluid and electrolyte imbalances in children are proportional to their age and include deficits, as well as fluid overload
 - 1) Infants are more vulnerable to FVD because of a greater volume of output to intake
 - 2) Infants' renal function is not fully developed, which limits the kidneys' ability to concentrate urine
 - 3) The body surface area is greater for infants and young children

B. Physical Assessment

- 1. Clinical assessment parameters
 - a. Clinical assessment should be performed on patient admission and monitored on a continuing basis throughout the course of the treatment
 - b. Shared responsibility with emphasis for nursing staff because of increased patient contact
 - c. Ongoing documentation
 - d. Report any unusual or abnormal findings to the licensed independent practitioner (LIP)
- 2. Fluid intake and output
 - a. Awareness of intake and output is needed for all patients, especially those with possible fluid and electrolyte imbalances
 - b. Intake measurement includes all oral fluids, enteral feedings, other tube feedings, and parenteral solutions
 - c. Individual volumes and the time of day are important for accurate comparison between intake and output and with body weight and should be totaled for a 24-hour period
 - d. Output measurement includes urine, diarrhea, fistula drainage, vomitus, and any drainage obtained through suctioning
 - e. Other fluid losses are important but not as easily measured
 - 1) Perspiration, respirations (particularly hyperventilation and respirator use), and drainage from lesions
 - 2) Document and quantify as much as possible, particularly in situations in which strict intake and output are required
 - 3) Time of day influences the findings
 - f. Comparison of intake and output totals is important
 - 1) When the total intake is greater than the output, fluid volume overload is possible
 - 2) When output exceeds intake, FVD is possible
 - 3) Electrolyte imbalances are a possible effect of FVDs or excesses
 - 4) Notify the LIP regarding abnormal findings
- 3. Renal system
 - a. Urine volume and concentration are the indicators of homeostasis
 - 1) Urine volume is the important component of the total output for a patient
 - 2) Low urine volume may indicate FVD
 - 3) High urine volume may suggest FVE
 - b. Urine concentration also may indicate fluid imbalances
 - 1) Urine is more concentrated with FVD
 - 2) Urine is less concentrated with FVE and functioning renal and endocrine (ADH and aldosterone levels) systems
 - 3) Document the findings and report the abnormalities to the LIP

4. Skin appearance and temperature
 - a. Skin turgor or tissue turgor
 - 1) Is assessed by pinching the skin and observing the results on release of the skin
 - 2) With normal fluid balance, skin quickly returns to its normal position
 - 3) With FVD, skin remains slightly elevated for several seconds
 - 4) Assessment sites for checking skin turgor include over the forearm, dorsum of the hand, forehead, and sternum, with the latter two areas generally considered the best sites
 - 5) Possible exceptions include checking skin turgor in infants; the best sites in infants are the abdominal area and the medial aspects of the thighs
 - b. Appearance and temperature of the skin
 - 1) May be affected by fluid and electrolyte imbalances
 - 2) Pale skin may result from peripheral vasoconstriction secondary to FVD
 - 3) Warm, flushed skin may occur from vasodilation, as found with metabolic acidosis
 - 4) Skin temperature may indicate imbalances
 - a) With hypovolemia, skin may be cool to the touch
 - b) With hypernatremic dehydration, skin temperature may be elevated
5. Special senses
 - a. The eyes, mouth, and tongue are also key indicators of fluid volume imbalances
 - b. Normally, the tongue reveals one longitudinal furrow
 - 1) Increase in number of furrows is indicative of reduced tissue volume related to FVD
 - 2) With hypernatremia, the tongue may appear red and swollen
 - c. Thirst: the presence or absence of thirst may indicate a fluid imbalance
 - 1) Ensures an adequate fluid volume as long as thirst is present, fluid is available, and losses are not abnormally high
 - 2) Is normally present but may be altered by certain conditions
 - a) Nausea
 - b) Vomiting
 - c) Altered states of consciousness
 - d) Inability to respond
 - e) Increasing age (older adult)
 - d. Tearing and salivation
 - 1) Normally present, may be absent when there is a deficit in fluid volume
 - 2) A tearless cry or the lack of salivation in an infant older than 3 months is a good indicator of FVD (becomes obvious with a fluid loss of greater than 5% of the TBW)
 - e. Appearance of the oral cavity
 - 1) Normally, the oral mucous membranes are moist
 - 2) Possibly altered in individuals who breathe mainly through the mouth
 - 3) Sticky, dry mucous membranes may be indicative of FVD or hypernatremia
6. Cardiovascular system
 - a. Edema develops when excessive fluid accumulates in the interstitial space
 - 1) Localized edema may occur as a result of inflammation
 - 2) Generalized edema may result from excessive sodium and water retention or from altered capillary hemodynamics
 - 3) Is more visible in dependent areas, such as the feet and ankles

- 4) Edema in the back and buttocks is common in patients confined to bed
- 5) Edema is often classified according to the severity of the swelling
 - a) Peripheral edema is best measured daily in the same area using a tape measure
 - b) Degree of pitting is best assessed over a bony prominence when there is cellular swelling
- b. Central venous pressure
 - 1) Measurement of mean right atrial pressure
 - 2) Readings should be taken with the patient in the same position each time
 - 3) Low readings may be related to a decrease in fluid volume
 - 4) High readings may be related to an increase in blood volume
- c. Other cardiovascular indicators
 - 1) Changes in the circulating volume of fluid are detected by the observation of the neck and hand veins
 - 2) In a dependent position and in the presence of a FVD, neck veins are flat and filling of hand veins is delayed
 - 3) With increased plasma volume, emptying of hand veins is delayed and neck veins appear engorged
7. Body weight
 - a. Body weight is used as an indicator of fluid status
 - b. One kilogram of body weight gained or lost is equal to approximately 1 L of fluid
 - c. Weight loss may be the result of several factors
 - 1) Can occur from loss of tissue associated with malnutrition
 - 2) Is often indicative of fluid loss
 - a) Rapid fluid loss of 2% of the TBW is indicative of mild FVD
 - b) A loss of 5% is indicative of moderate deficit
 - c) A loss of 8% is indicative of severe deficit
 - 3) Severe FVD is not always signaled by a loss of body weight, particularly when the fluid is pulled from the vascular system and trapped in a space or cavity, such as in third spacing
 - d. Rapid weight gain often indicates an increased fluid volume
 - 1) Gain can occur in any fluid compartment
 - a) Overload in vascular space as a result of excessive administration of intravenous fluids or an excess of sodium
 - b) Body's inability to excrete fluid (e.g., renal disease and ascites)
 - 2) Percentage of weight gain indicates severity of the excess
 - a) Rapid weight gain of 2% indicates mild FVE
 - b) 5% weight gain indicates moderate FVE
 - c) 8% weight gain indicates severe FVE
 - e. Daily weight recordings are used for comparisons to detect losses or gains
 - 1) Weight taken at the same time every day
 - 2) Best time is in the morning after voiding and before eating
 - 3) For accuracy, same type of scales should be used and same type of clothing should be worn each day
 - 4) Dry clothing should be worn to prevent additional nonbody weight
 - 5) Findings should be recorded in a manner that allows for easy day-to-day comparison of losses or gains
8. Neurological system
 - a. Changes may occur in sensorium, including levels of awareness, orientation, and consciousness from acid–base and electrolyte imbalances

- 1) Degree of changes is directly related to severity of imbalance
 - 2) Restlessness and confusion may result from FVD
 - b. Disturbances in neuromuscular excitability may occur as a result of electrolyte imbalances
 - 1) Increased excitability is seen with calcium and magnesium deficits
 - 2) Depressed neuromuscular activity is seen with excesses of calcium and magnesium
 - c. Neuromotor symptoms result from metabolic alkalosis, which decreases calcium ionization
 - 1) Tingling of fingers and toes
 - 2) Hypertonic muscles
 - 3) Dizziness
 - d. Chvostek's and Trousseau's signs are useful in determining calcium and magnesium imbalances
 - 1) Chvostek's sign is elicited by tapping facial nerve slightly anterior to ear lobe
 - 2) Positive Chvostek's sign is indicated by unilateral contraction of facial and eyelid muscles
 - 3) Trousseau's sign is created by inflating blood pressure cuff placed on the upper arm to a level above systolic pressure
 - 4) Positive Trousseau's sign is indicated by hand spasm, resulting from decreased blood supply
9. Vital signs
- a. Temperature
 - 1) Elevated temperature may result in loss of fluids and electrolytes from excessive sweating
 - 2) May increase with FVD
 - 3) May decrease with hypovolemia
 - b. Pulse
 - 1) Increased heart rate in an attempt to maintain cardiac output with a FVD; pulse is usually weak with FVD and full and bounding with FVE
 - 2) Increased heart rate may result from potassium and magnesium deficits and sodium excess
 - 3) Decreased heart rate may result from severe hyperkalemia or hypermagnesemia
 - 4) Irregularities in heart rate with potassium imbalances or magnesium deficit
 - 5) Electrocardiogram (ECG) changes (e.g., irregularity) are possible with potassium, calcium, and magnesium excesses or deficits
 - c. Respirations
 - 1) Increased respiratory rate may lead to increased fluid loss
 - 2) FVD is possible from increased production of respiratory secretions
 - 3) Shortness of breath and moist crackles seen with FVE
 - 4) Mechanical ventilation is associated with fluid gain
 - 5) Deep, rapid respirations are indicative of respiratory alkalosis or compensation for metabolic acidosis
 - 6) Slow, shallow respirations are indicative of respiratory acidosis or compensation for metabolic alkalosis
 - d. Blood pressure
 - 1) Increased blood pressure with FVE
 - 2) Decreased blood pressure with FVD

- 3) Decreased blood pressure with magnesium excess from decreased vascular resistance
- 4) Changes in blood pressure with sodium imbalances secondary to fluid volume levels
- 5) Postural hypotension possible with hypokalemia

C. Laboratory Data

1. Serum osmolality
 - a. Used to measure the number of solutes in blood
 - b. Primarily affected by the serum sodium content
 - c. Used in assessment of hydration status and hyponatremia
 - d. Concentration increases with dehydration, hyperglycemia, and elevated blood urea nitrogen (BUN)
 - e. Concentration decreases with FVE
 - f. Normal range: 280 to 300 mOsm/kg
2. Hematocrit
 - a. Measures the percentage of red blood cells as compared with the plasma in whole blood
 - b. Normal range is 37% to 51% for males and 35% to 47% for females
 - c. Decreases with FVE
 - d. Increases in dehydration
3. BUN
 - a. Measures the amount of urea, the end product of protein metabolism, found in the serum
 - 1) Formed in the liver
 - 2) Picked up by the circulating blood
 - 3) Excreted through the renal system
 - b. Normal adult level: 5 to 20 mg/dL
 - c. Low BUN may result from overhydration, infusion therapy, and low protein intake
 - d. Increased BUN levels result from dehydration, excessive protein intake, diabetes mellitus, gastrointestinal bleeding, trauma, and renal disease
4. Serum creatinine
 - a. Measurement of the serum level of creatinine, a by-product of muscle catabolism, is directly proportional to the muscle mass
 - b. Circulates in the blood, is filtered by glomeruli, and is not reabsorbed by the renal tubules
 - c. Generally not affected by diet or fluid levels and is a more sensitive indicator of renal disease
 - d. Normal adult level: 0.6 to 1.6 mg/dL
5. Serum electrolytes
 - a. Measures the electrolytes found in the body
 - 1) Sodium
 - 2) Potassium
 - 3) Calcium
 - 4) Magnesium
 - 5) Phosphorus
 - 6) Chloride
 - 7) Bicarbonate
 - b. Affected by fluid and electrolyte intake and excretion

6. Arterial blood gases (ABGs)
 - a. Measurement of pH, PaCO_2 , PaO_2 , bicarbonate, and base excess levels
 - b. Used to evaluate acid–base balance
7. Urinary specific gravity
 - a. Measures the quantity and nature of particles in the urine
 - b. Normal value is 1.003 to 1.030
 - c. Affected by hydration status, renal status, and the number and size of particles in urine; large molecules, such as glucose, protein, and radiologic contrast media, will elevate the results out of proportion to actual concentration
8. Urine osmolality
 - a. Measures the number of particles, ions, and molecules in urine
 - b. Not overly influenced by the size of the molecules
 - c. Urine osmolality in conjunction with serum osmolality is generally considered a more accurate indication of renal concentrating ability than is the specific gravity measurement



III. Fluid Volume Imbalances

A. FVE or Hypervolemia

1. Description
 - a. An increase in the fluid volume of the extracellular compartment
 - b. Can occur in the intravascular or interstitial compartments, or both
 - c. Generally, the same proportion of water and electrolytes is retained
2. Etiology
 - a. Intake of sodium and water
 - 1) Excessive intake of intravenous solutions
 - a) Rapid administration of solutions
 - b) Continuous or excessive use of sodium-containing solutions leading to water retention
 - 2) Ingestion of sodium-containing foods in patients with renal or cardiac disease resulting in increased thirst and fluid intake
 - 3) Oral or intravenous medications containing sodium may lead to fluid retention
 - b. Conservation of water and sodium
 - 1) Abnormal ADH production or increased aldosterone, such as occurs after surgery
 - 2) Circulating intravascular volume often decreased with congestive heart failure, renal diseases, and cirrhosis of the liver
 - a) Subsequent renin and aldosterone production leads to increased water and sodium conservation
 - 3) Corticosteroid therapy will increase water and sodium retention
 - c. Fluid shifts
 - 1) Shift of fluid from interstitial to vascular space may increase FVE
 - 2) Possible during the treatment of burns or with the use of hypertonic intravenous solutions or medications
 - d. Inability to excrete fluids
 - 1) Secondary to renal disease resulting in decreased renal function leading to decreased output
 - 2) Continuous fluid ingestion then leads to an intake that exceeds output

3. Signs and symptoms (dependent on severity and location of excess)
 - a. Elevated blood pressure
 - b. Increased pulse rate, bounding
 - c. Possible third heart sound (S3 or ventricular gallop)
 - d. Increased central venous pressure
 - e. Distended neck veins
 - f. Engorged peripheral veins with slowed hand vein emptying
 - g. Pulmonary edema
 - 1) Shortness of breath
 - 2) Moist crackles
 - 3) Increased respirations
 - h. Body weight increases as fluid increases in the extracellular compartment (exception: if fluid excess is caused by fluid shift between compartments)
 - i. Peripheral edema, possibly pitting edema in dependent areas, such as the feet and ankles
 - 1) Determined by applying pressure for several seconds
 - 2) If edema present, the indentation from finger pressure remains
 - 3) Severity is measured by the size of indentation and the length of time required for the indentation to disappear
 - j. Ascites
 - 1) Subsequent shortness of breath as a result of increased pressure on diaphragm
 - 2) Drop in cardiac output as a result of poor right ventricle filling
4. Diagnostic data
 - a. Hematocrit: decreased as a result of hemodilution
 - b. ABGs: decreased oxygen content, decreased PaCO₂, and increased pH
 - c. Chest X-ray: pulmonary vascular congestion
 - d. Serum sodium and osmolality: possibly decreased as a result of excessive fluid retention, particularly if renal disease is present
 - e. BUN and creatinine levels: increased with renal or cardiac failure
 - f. Urinary specific gravity: decreased as kidneys try to excrete excessive fluid
5. Treatment
 - a. Elimination of precipitating factors and return of ECF to a normal level
 - b. Sodium and water restriction
 - c. Diuretic therapy
6. Nursing interventions
 - a. Assess vital signs with focus on bounding pulse, body weight, and edema
 - b. Monitor intake and output
 - c. If diuretic therapy is used, document the response
 - d. Observe for any signs of overcorrection resulting in a FVD
 - e. Monitor for symptoms of related conditions (e.g., pulmonary edema and ascites) such as constant irritating cough, difficulty in breathing, neck and hand vein engorgement, and lung crackles

B. FVD or Hypovolemia

1. Description
 - a. Decreased fluid volume in the extracellular compartment
 - b. With fluid loss, electrolytes are lost, further complicating the body's ability to retain water
 - c. May be related to acid-base, fluid, or electrolyte imbalances

2. Etiology
 - a. Abnormal fluid loss
 - 1) Gastrointestinal tract is the most common route
 - a) Vomiting
 - b) Suctioning
 - c) Diarrhea
 - d) Fistulas
 - e) Laxative abuse
 - 2) Fluid lost through the skin
 - a) Insensible fluid loss is used as the mechanism to regulate the temperature within the body
 - b) Elevated temperatures as a result of illness or strenuous activity cause body to dissipate heat, resulting in increased fluid loss
 - c) Any breaks in the skin, such as burns and wounds, allow fluid to escape the body
 - 3) Hemorrhage causes rapidly decreasing fluid volume in the intravascular space
 - a) Surgery
 - b) Trauma
 - c) Bleeding disorders
 - d) Accidental disconnection of administration set from the vascular access device
 - 4) Renal disease or the use of diuretics
 - 5) Fluid shifting from one area to another, where it cannot be readily used by the body (third spacing)
 - a) Ascites
 - b) Internal bleeding
 - c) Burns
 - d) Fluid trapped in bowel or body cavities, such as the pleural, pericardial, or peritoneal spaces
 - b. Decreased intake
 - 1) Failure to prescribe or deliver adequate amounts of intravenous solutions
 - 2) Lack of available fluids, such as with infants or older adults who are physically unable to get to a fluid source
 - 3) Alteration of the thirst mechanism; older adults have a decreased sense of thirst and may not seek adequate replacement
 - 4) Difficulty communicating the need for fluid
 - a) Infants
 - b) Comatose patients
3. Signs and symptoms (directly related to severity of the deficiency)
 - a. Weight loss particularly with rapid fluid loss, except with third spacing
 - b. Decreased central venous pressure, slow hand filling, decreased blood pressure, and postural hypotension
 - c. Flattened jugular veins in the supine position
 - d. Neurological indicators such as muscle weakness, dizziness, lethargy, and confusion from decreased tissue perfusion
 - e. Weak, rapid pulse in an attempt to maintain an adequate circulating volume within the vascular system
 - f. Decreased urine output as the body tries to conserve fluid (in hypovolemic states, urinary output typically is <30 mL/hour)

- g. Decreased skin turgor
- h. Soft, small tongue with several longitudinal furrows, instead of the normal one furrow
- i. Pinched facial expression
- j. Soft, sunken eyes
- k. With severe losses, patient may go into shock
 - 1) Cool, clammy extremities
 - 2) Diaphoresis
 - 3) Sharp drop in urine output
 - 4) Coma
- 4. Diagnostic data
 - a. Serum BUN: increased above 20 mg/dL
 - b. Hematocrit: increased (unless deficit is caused by bleeding)
 - c. Serum electrolytes, serum osmolality and acid-base balance: dependent on the cause of deficit and the type of fluid lost
 - d. Urinary specific gravity: increased
 - e. Urinary osmolality increased
- 5. Treatment
 - a. Correction of the cause of the deficit
 - b. Restoration of the ECF level
 - c. Initially, fluid replacement with an isotonic electrolyte solution, such as lactated Ringer's
 - d. Replacement rate is dependent on the severity of the deficit
 - e. Once volume replacement is achieved, replacement solutions are chosen to provide free water to assist the kidneys in excreting wastes. Fluid challenge may be considered if oliguria is present to determine the cause
 - 1) Intravenous solutions are administered according to a specific plan
 - 2) Patient is monitored closely
 - a) Increased urinary output indicates that oliguria was related to the hypovolemia
 - b) No change in the output possibly indicates the cause to be renal failure or decreased cardiac function
- 6. Nursing interventions
 - a. Assess vital signs, urinary output, hemodynamic pressures, laboratory findings, and body weight
 - b. Use caution in fluid replacement to avoid fluid overload
 - c. Monitor the rate of infusion administration
 - d. With rehydration, look for a drop in hematocrit that may necessitate blood administration



IV. Electrolyte Imbalances

A. Sodium (Na^+)

- 1. Overview
 - a. The main cation in the ECF
 - b. Important physiologic functions
 - 1) Controls water distribution
 - 2) Maintains the volume of ECF
 - 3) Promotes irritability of nerve and muscle tissue

- 4) Transmits nerve impulses
- 5) Maintains acid–base balance
- c. Normal serum sodium value: 135 to 145 mEq/L
- 2. Hyponatremia
 - a. Definition
 - 1) Serum sodium deficit
 - 2) Level below 135 mEq/L
 - b. Etiology
 - 1) Excessive intake of water
 - a) Administration of excessive water or dextrose-containing intravenous solutions resulting in water excess (edema) and dilution of sodium concentration
 - b) Excessive fluid intake as a result of a chronic psychiatric disorder, psychogenic polydipsia, resulting in dilutional hyponatremia
 - c) Syndrome of inappropriate antidiuretic hormone (SIADH): inappropriate secretion of ADH resulting in excessive water retention
 - 2) Excessive sodium loss
 - a) Diuretics
 - b) Adrenal insufficiency resulting in stimulation of the ADH and increased water retention leading to hyponatremia
 - c) Excessive sweating, such as occurs in children with cystic fibrosis, increasing loss of sodium
 - c. Signs and symptoms (dependent on the cause and rate of onset)
 - 1) A decrease in serum osmolality may result in fluid being pulled into the cells. Overhydration of brain cells ($\text{Na}^+ < 115 \text{ mEq/L}$) results in nausea, vomiting, focal weakness, muscular twitching or cramps, confusion, and coma
 - 2) Deficit caused by water gain results in same symptoms of hypervolemia
 - a) Weight gain
 - b) Peripheral edema and fingerprinting
 - 3) Deficit caused by fluid loss results in signs and symptoms of hypovolemia
 - a) Hypotension
 - b) Dizziness
 - d. Diagnostic data
 - 1) Serum sodium level: below 135 mEq/L
 - 2) Serum osmolality: decreased below 280 mOsm/L
 - 3) Urine sodium and specific gravity: increased with SIADH and decreased with excessive sodium losses
 - 4) Hematocrit: above normal when FVD is present
 - e. Treatment
 - 1) Dependent on etiology
 - 2) Deficit as a result of loss of fluids
 - a) Sodium and fluid replacement is done orally or with isotonic intravenous solutions
 - b) Hypertonic sodium chloride (3%) intravenous solutions are used for extremely low sodium levels
 - 3) Deficit related to fluid gain
 - a) Diuretics to excrete excess fluid
 - b) Hypertonic sodium chloride solutions along with loop diuretics are used for severe hyponatremia

- 4) Deficit as a result of SIADH
 - a) Removal of cause
 - b) Diuretics
 - c) Fluid restriction
 - d) Medication to inhibit the action of ADH (chronic SIADH)
- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor laboratory values
 - 3) Monitor intake and output and daily weight
 - 4) Administer medications and intravenous solutions as ordered
 - 5) Document observations and interventions, especially when administering hypertonic sodium chloride
 - 6) Notify the LIP of abnormal findings
3. Hypernatremia
 - a. Definition
 - 1) Serum sodium excess
 - 2) Serum level above 145 mEq/L
 - b. Etiology
 - 1) Excessive sodium
 - a) Intravenous administration of sodium-containing solutions or medications
 - b) Decreased excretion of sodium, such as with primary aldosteronism
 - 2) Increased water loss
 - a) Burns
 - b) Diaphoresis
 - c) Increased insensible fluid loss from the lungs
 - d) Impaired thirst or inability to get water (normally with hypernatremia, thirst response is initiated and thirst satisfied by fluid intake, which replaces volume deficit)
 - e) Osmotic diuresis, such as from administration of mannitol or elevated glucose level
 - f) Diabetes insipidus (a lack of functioning ADH)
 - c. Signs and symptoms (many related to FVD)
 - 1) Moderate imbalance first evident by restlessness, fatigue, and weakness; more prominent signs develop as cells become more dehydrated
 - 2) Neurological signs
 - a) Agitation and disorientation
 - b) Delirium
 - c) Seizures
 - d) Coma
 - 3) Marked thirst
 - 4) Dry and sticky mucous membranes
 - 5) Decreased saliva and tears
 - 6) Rough, red, and dry tongue possibly becoming swollen, creating speech difficulties
 - 7) Elevated temperature
 - 8) Flushed skin
 - d. Diagnostic data
 - 1) Serum sodium level: elevated above 145 mEq/L
 - 2) Serum osmolality: elevated above 295 mOsm/kg

- 3) Chloride may be elevated
- 4) Central venous pressure: low due to fluid loss
- 5) Urinary specific gravity: increases as the kidneys attempt to conserve water
- 6) ADH or vasopressin levels: if diabetes insipidus is suspected
- e. Treatment
 - 1) Dependent on etiology
 - 2) Gradually restore sodium to a normal level over a 48-hour period of time
 - 3) Related to sodium excess: sodium restriction
 - 4) Related to water loss
 - a) Replacement with oral fluids or intravenous solutions containing hypotonic electrolyte solutions or 5% dextrose in water
 - b) Replacement is done with caution to prevent rapid correction leading to a possible shift of water into brain cells, resulting in cerebral edema
 - c) Diuretics are used to decrease the polyuria associated with hypernatremia related to central diabetes insipidus or nephrogenic diabetes insipidus
- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor laboratory test results with emphasis on serum sodium and serum osmolality
 - 3) When infusion therapy is administered, closely monitor for signs of cerebral edema and immediately report any signs to the LIP
 - 4) Monitor for seizures
 - 5) Institute precautions as needed for patient orientation and safety secondary to confusion, delirium, and seizures

B. Potassium (K^+)

1. Overview
 - a. The main cation in the ICF; small amount of potassium in the ECF
 - b. Balance of intracellular and extracellular potassium is maintained through the action of the sodium–potassium pump
 - c. Kidneys act as the main regulators
 - 1) Kidneys respond to increased serum levels of potassium by promoting greater potassium excretion in urine
 - 2) Increased levels stimulate aldosterone production, leading to increased sodium and water retention and potassium excretion
 - d. Maintenance of adequate levels is dependent on regular replenishment
 - e. Important physiologic functions
 - 1) Controls osmotic pressure to regulate fluid volume within the cells
 - 2) Promotes nerve impulses
 - 3) Contracts skeletal, smooth, and cardiac muscles
 - 4) Controls hydrogen ion (H^+) to assist in regulating acid–base balance
 - 5) Helps to maintain neuromuscular activity, particularly the cardiac system
 - f. Normal serum potassium level: 3.5 to 5.3 mEq/L
2. Hypokalemia
 - a. Definition
 - 1) Potassium deficit

- 2) Serum level below 3.5 mEq/L; usually reflects a real deficit in total potassium
- 3) Common clinical conditions contribute to this deficit
- b. Etiology
 - 1) Potassium loss (major cause)
 - a) Renal: main cause is the use of diuretics, particularly loop diuretics (furosemide and ethacrynic acid) and thiazides; excess use of glucocorticoids and use of drugs such as sodium penicillin
 - b) Increased aldosterone levels
 - c) Abnormal losses through gastrointestinal fluids, such as gastric suctioning, vomitus, diarrhea, and fistulas
 - d) Severe trauma
 - e) Osmotic diuresis
 - f) Increased sweating
 - 2) Inadequate intake
 - a) Inadequate replacement with parenteral or parenteral nutrition solutions
 - b) Potassium-poor diet (rare)
 - c) Poor dietary intake associated with anorexia nervosa, bulimia
 - 3) Stress
 - a) Physical or emotional stress leads to increased release of aldosterone and epinephrine, which increases urinary potassium loss and shifts potassium into the cells
 - 4) Potassium moves into cells from extracellular space
 - a) Alkalosis
 - b) Tissue repair from trauma or burns
 - c) Increased glucose (total nutrient admixture solutions)
 - d) Excessive administration of insulin
- c. Signs and symptoms (level generally below 3.0 mEq/L before indicators are present)
 - 1) Slowed muscle and nerve impulse transmission
 - a) Fatigue
 - b) Leg cramps
 - c) Paresthesias
 - d) Muscle weakness
 - e) Drowsiness
 - f) Diminished deep tendon reflexes
 - g) Nausea
 - h) Vomiting
 - i) Decreased bowel motility
 - 2) Altered cardiac function
 - a) Irregular pulse
 - b) Dysrhythmias
 - c) Increased sensitivity to digitalis
- d. Diagnostic data
 - 1) Serum potassium level below 3.5 mEq/L
 - 2) ABGs: metabolic alkalosis
 - 3) Urinary potassium level: some loss because the kidneys have difficulty conserving potassium
 - 4) ECG: ST segment depression, flattened T waves, and a U wave possibly superimposed on the T

- e. Treatment
 - 1) Mild depletion treated with diet or supplements
 - 2) Extremely low levels are usually treated with intravenous potassium
 - a) Potassium chloride (most frequently used)
 - b) Potassium acetate
 - c) Potassium phosphate
 - 3) Administration of a nonpotassium-containing solution may be necessary first to ensure adequate hydration and renal function
 - 4) Potassium chloride (KCl) must be diluted before administration
 - a) Never administer via intravenous push
 - b) KCl should be added to nondextrose solution such as isotonic saline
 - c) Concentration generally does not exceed 40 mEq/L
 - d) Flow rate should not exceed 20 mEq/hour, except in cases of severe depletion in which maximum concentration should not exceed 80 mEq/L
 - e) Caution is necessary when administering high concentrations at a rapid rate because of the potential for cardiac side effects
- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Assess renal function prior to initiation of potassium replacement
 - 3) Administer properly diluted potassium admixtures
 - 4) Be alert for reports of pain related to intravenous administration
 - a) Decreased flow rate
 - b) Further dilute admixture
 - 5) Monitor ECG readings on an ongoing basis
 - 6) Monitor serum potassium levels
- 3. Hyperkalemia
 - a. Definition
 - 1) Potassium excess
 - 2) Serum level above 5.3 mEq/L
 - 3) Frequently associated with renal disease
 - b. Etiology
 - 1) Increased intake
 - a) Intravenous administration of inappropriate amounts of potassium
 - b) Inadequately diluted potassium-containing solutions
 - c) Renal disease; even small amounts of potassium may be problematic
 - d) Aged blood; potassium is released with breakdown of blood cells and may become excessive
 - 2) Decreased excretion
 - a) Renal disease—acute or chronic failure
 - b) The use of potassium-sparing diuretics may result in fluid volume elimination greater than potassium excretion; similar problems are possible with any ECF depletion
 - c) Decreased secretion of aldosterone
 - 3) Potassium shift from the cells to ECF
 - a) Metabolic acidosis causes positively charged hydrogen ions to enter the cells and forces potassium cations out of the cells
 - b) Hyperglycemia due to insulin deficiency may pull potassium from the cells as water moves out of the cells in an attempt to dilute concentrated intravascular glucose content

- c) Breakdown of cells allows excessive potassium to enter extracellular compartments as a result of burns, trauma, and sepsis
- 4) Improper blood drawing technique in obtaining blood samples
 - a) False high levels of potassium is considered if levels are excessive without any clinical signs
 - b) Tourniquet left on too long
 - c) Hemolysis of the blood cells
 - d) Delayed separation of serum and cells
 - e) Blood samples drawn in close proximity to an infusing potassium-containing intravenous solution
- c. Signs and symptoms
 - 1) Clinical picture is usually related to altered cardiac or neuromuscular activity
 - 2) Impulses necessary for sending messages to the nerves and muscles are altered, creating an increase in neuromuscular excitability
 - a) Paresthesias (face, tongue, hands, and feet)
 - b) Gastrointestinal hyperactivity (diarrhea, nausea, and abdominal cramping)
 - c) Irritability
 - d) ECG changes: tall thin T waves prolonged PR interval; ST segment depression; widened QRS; and loss of P wave
 - 3) As the level increases, the cardiac and neuromuscular cells of the lower extremities are unable to handle the rapid signals
 - a) Weakness progressing to body and arms
 - b) Heart rate affected, eventually leading to atrial or ventricular fibrillation and heart block
- d. Diagnostic data
 - 1) Serum potassium level: above 5.3 mEq/L
 - 2) ABGs: metabolic acidosis
 - 3) ECG: high-tented T waves, absence of P waves, prolonged QRS complexes, indicating impending cardiac arrest
- e. Treatment
 - 1) Eliminate the cause
 - 2) Mild excesses are treated with cation exchange resins
 - 3) Intravenous hypertonic glucose (usually 10%) and insulin are used for temporary treatment of moderate-to-severe excesses
 - a) Potassium shifts back into the cells
 - b) Once started, this form of treatment continued until normal levels are attained
 - 4) Sodium bicarbonate
 - a) Temporary treatment that shifts potassium into the cells
 - b) Onset of action is 5 to 10 minutes, with reduction lasting for only 1 to 2 hours
 - 5) Calcium gluconate
 - a) Used in severe cases when cardiac abnormalities are present
 - b) The effects of potassium on the myocardium are antagonized
 - c) Only a temporary effect, lasting approximately 1 hour
 - 6) Dialysis including hemodialysis or peritoneal dialysis is done to remove excess potassium in severe hyperkalemia
- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor intake and output and serum potassium level

- 3) Evaluate ECG for changes
- 4) Monitor patient for signs and symptoms of potassium shift, rebound hypoglycemia, or sodium excess during administration
- 5) Use calcium gluconate cautiously with patients receiving digitalis
 - a) Monitor ECG
 - b) Observe for signs of digitalis toxicity
 - c) Stop medication immediately if bradycardia occurs

C. Calcium (Ca^{++})

1. Overview
 - a. Cation with important physiologic functions
 - 1) Maintains skeletal elements; calcium is needed for strong bones and teeth
 - 2) Regulates neuromuscular activity
 - 3) Influences enzyme activity
 - 4) Converts prothrombin to thrombin necessary to hold cells together
 - b. Available as ionized, bound, and complex forms
 - 1) Approximately 50% of the total volume is in ionized form
 - 2) Slightly less volume occurs in bounded form
 - 3) Small percentage is in complex form
 - c. Approximately 1% to 2% of the total calcium is found in the ECF
 - d. Regulated by the parathyroid hormone and calcitonin
 - e. Eliminated through the gastrointestinal tract, urinary tract, and sweat; it is also deposited in the bone
 - f. Inverse proportional relationship with phosphorus
 - g. Normal serum calcium level is 8.2 to 10.7 mg/dL (ionized portion is approximately half the total value)
2. Hypocalcemia
 - a. Definition
 - 1) Calcium deficit
 - 2) Serum level below 8.2 mg/dL or ionized calcium level below 4.6 mEq/L
 - b. Etiology
 - 1) Reduced intestinal absorption
 - a) Vitamin D deficiency
 - b) Decreased intake
 - c) Small bowel disease
 - d) Continuous infusion of calcium-free intravenous solutions
 - 2) Increased calcium losses
 - a) Diuretics
 - b) Renal disease
 - c) Fistulas
 - d) Burns
 - e) Infections
 - 3) Altered regulation: hypoparathyroidism secondary to surgery or injury to the parathyroid glands
 - 4) Phosphorus or magnesium imbalances
 - a) Increased phosphorus levels lead to decreased calcium levels because of reciprocal relationship of calcium and phosphorus
 - b) Increased bone uptake of calcium results in decreased magnesium levels in bone

- 5) Other causes
 - a) Acute pancreatitis
 - b) Alkalosis
 - c) Decreased serum albumin
- c. Signs and symptoms (primarily related to neuromuscular activity)
 - 1) Numbness and tingling of the fingers, toes, and circumoral region
 - 2) Tetany
 - 3) Convulsions
 - 4) Hyperactive deep tendon reflexes
 - 5) Muscle cramps
 - 6) Positive Trousseau's and Chvostek's signs
 - 7) Mental changes
 - a) Depression
 - b) Confusion
 - 8) Respiratory effects (seen with more severe deficits)
 - a) Dyspnea
 - b) Stridor
 - c) Spasm of the laryngeal muscles
- d. Diagnostic data
 - 1) Total calcium below 8.5 mg/dL or ionized calcium level below 4.6 mEq/L
 - 2) Serum phosphorus level: may be elevated greater than 2.6 mEq/L
 - 3) Serum magnesium: decreased
 - 4) ECG: prolonged QT interval and ST segment
 - 5) Potential for increased serum creatinine from renal insufficiency
- e. Treatment
 - 1) Emergency treatment is required because acute hypocalcemia is a potentially life-threatening situation
 - 2) Identify cause for prompt initiation of treatment
 - 3) Administration of oral or intravenous calcium
 - a) Calcium gluconate (drug of choice)
 - b) Calcium chloride (more concentrated form)
 - 4) Caution is used in intravenous calcium administration because extravasation may result in cellulitis, necrosis, and sloughing of tissue
- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor laboratory values and ECG
 - 3) Initiate safety precautions if tetany is present
 - 4) Institute precautions to address respiratory problems
- 3. Hypercalcemia
 - a. Definition
 - 1) Calcium excess
 - 2) Serum ionized calcium level above 5.1 mEq/L or total serum calcium level above 10.7 mg/dL
 - b. Etiology
 - 1) Calcium loss from bone
 - a) Hyperparathyroidism
 - b) Malignancy (as a result of the release of parathyroid hormone increasing the effects on bone, releasing calcium to the serum; bone metastasis that alters bone metabolism)
 - c) Prolonged immobilization or multiple fractures resulting in calcium release

- d) Certain medications predispose individuals to hypercalcemia (e.g. excessive use of calcium antacids)
- 2) Increased intake
 - a) Excessive administration of intravenous calcium
 - b) Use of calcium-containing antacids
- 3) Decreased excretion of calcium
 - a) Renal disease
 - b) Hyperparathyroidism
 - c) Medications such as thiazides
- 4) Excess ionized calcium level from acidosis
- c. Signs and symptoms (vary according to serum level)
 - 1) Initial symptoms may be misleading because of an association with a variety of disorders
 - a) Anorexia
 - b) Fatigue
 - c) Lethargy
 - d) Muscle weakness
 - e) Nausea
 - f) Vomiting
 - g) Dehydration
 - h) Constipation
 - 2) Decreased ability of the kidneys to concentrate urine
 - a) Polyuria
 - b) Polydipsia
 - 3) Other signs and symptoms
 - a) Deep bone pain
 - b) Flank pain
 - c) Pathologic fractures
 - d) Generalized osteoporosis
 - e) Personality changes ranging from neurotic behavior to psychosis
- d. Diagnostic data
 - 1) Total serum calcium level increased above 10.7 mg/dL or ionized calcium above 5.5 mEq/L
 - 2) ECG: shortened ST segment and QT interval, a widened and rounded T wave, and a slightly widened QRS and PR interval
 - 3) Radiography: reveals severe osteoporosis
- e. Treatment
 - 1) Elimination of cause
 - 2) Reduction of calcium level
 - 3) Intravenous administration of 0.9% sodium chloride
 - a) In the absence of renal disease to dilute the body fluids
 - b) Helpful in eliminating calcium for severe hypercalcemia
 - 4) Furosemide (Lasix) loop diuretic may be used to increase urinary excretion of calcium and prevent volume overload
 - 5) Calcitonin for temporary correction
 - 6) Chemotherapy or radiation therapy to reduce the tumor if the excess is related to malignancy
 - 7) Corticosteroids to reduce bone turnover and reabsorption by the renal system
 - 8) Administer bisphosphonates to inhibit bone reabsorption

- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor patient for indicators of calcium excess
 - a) Serum level
 - b) ECG
 - c) Renal function
 - 3) Administer medications as ordered while observing for side effects

D. Magnesium (Mg^{++})

- 1. Overview
 - a. Cation located primarily in the intracellular cells of bones and muscles
 - b. Small percentage is found in the ECF compartment
 - c. Excreted mainly by the kidneys
 - d. Close to one third of magnesium is bound to protein
 - 1) Most of the remaining electrolyte occurs as free or ionized
 - 2) Serum levels are not an accurate reflection of total amount of magnesium in body because serum contains a very small amount
 - e. Important physiologic functions
 - 1) Activates enzymes
 - 2) Affects protein and carbohydrate metabolism
 - 3) Directly acts on the myoneural junction, affecting neuromuscular irritability and contractility
 - 4) Acts on skeletal muscle by depressing acetylcholine release at the synaptic junction
 - 5) Affects cardiovascular system by contributing to vasodilation, leading to changes in blood pressure and cardiac output
 - f. Levels and actions of magnesium are interdependent with those of calcium and potassium
 - g. Normal serum magnesium level: 1.8 to 3.0 mg/dL
- 2. Hypomagnesemia
 - a. Definition
 - 1) Magnesium deficit
 - 2) Serum level below 1.8 mg/dL
 - b. Etiology
 - 1) Decreased intake
 - a) Dietary insufficiency
 - b) Refeeding after starvation
 - c) Continuous use of magnesium-free parenteral solutions
 - 2) Improper gastrointestinal absorption
 - a) Malabsorption syndrome
 - b) Small bowel resection
 - c) Colitis
 - 3) Increased elimination
 - a) Prolonged diarrhea
 - b) Vomiting
 - c) Nasogastric suctioning
 - d) Intestinal fistulas
 - e) Some medications, including laxatives, diuretics, Cisplatin (Platinol), Amphotericin B (Fungizone), and aminoglycosides, may enhance excretion through the renal system

- 4) Chronic alcoholism
 - a) Primary cause
 - b) Result of poor dietary intake, intestinal malabsorption, diarrhea, and increased urinary output
- c. Signs and symptoms
 - 1) Neurological
 - a) Positive Trousseau's and Chvostek's signs
 - b) Increased reflexes
 - c) Tremors
 - d) Convulsions
 - e) Tetany
 - f) Paresthesias
 - g) Painfully cold sensations in hands and feet
 - 2) Mentation
 - a) Depression
 - b) Personality disorders
 - c) Confusion
 - d) Delirium
 - 3) Cardiovascular
 - a) Dysrhythmias, such as ventricular tachycardia and ventricular fibrillation
 - b) Increased risk for digitalis toxicity
- d. Diagnostic data
 - 1) Serum magnesium level: below 1.8 mg/dL
 - 2) Urine magnesium level: increased
 - 3) Serum calcium: often low
 - 4) ECG: prolonged PR interval and a widening QRS complex, depending on the severity of the deficit
 - 5) Serum potassium decreased due to the failure of the cellular sodium-potassium pump
- e. Treatment
 - 1) Prevention is the key to management
 - 2) Oral, intramuscular, or intravenous supplements once the deficit occurs
 - a) Oral supplements to treat mild-to-moderate deficits and continuing losses
 - b) Intravenous magnesium (magnesium sulfate as drug of choice) in 5% dextrose in water for treating severe deficits
- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Consider the degree of loss and renal status when giving magnesium because it is eliminated by the kidneys
 - 3) Ensure urinary output of at least 100 mL every 4 hours
 - 4) Periodically check reflexes
 - a) Keep in mind that deep tendon reflexes disappear just before depressed respirations
 - b) Notify the LIP if reflex is absent
 - 5) Assess vital signs frequently to detect any decreases in blood pressure or labored respirations when large doses of magnesium are given
 - 6) Monitor serum levels
 - 7) Prepare to counteract respiratory arrest before administering magnesium in case the magnesium level becomes excessive

- 8) Institute seizure precautions
 - 9) Stop the intravenous infusion immediately if any side effects appear
 - 10) Have calcium gluconate readily available to reverse signs of magnesium overload
3. Hypermagnesemia
- a. Definition
 - 1) Magnesium excess
 - 2) Serum level above 3.0 mg/dL
 - b. Etiology
 - 1) Decreased elimination
 - a) Renal disease is the major cause; often associated with additional magnesium intake
 - b) Endocrine disturbances, including hypothyroidism, hyperparathyroidism, and Addison's disease
 - 2) Increased intake
 - a) Medications including laxatives and antacids
 - b) Continued or excessive intravenous administration, such as with treatment for eclampsia
 - c. Signs and symptoms (usually not present until levels become excessively elevated)
 - 1) Interference with neuromuscular transmission
 - a) Increased muscle weakness
 - b) Paralysis
 - c) Decreased deep tendon reflexes
 - d) Respiratory muscle depression with eventual paralysis (at higher levels)
 - 2) Gastrointestinal
 - a) Nausea
 - b) Vomiting
 - 3) Cardiovascular (become increasingly severe with rising levels)
 - a) Flushing and sensation of skin warmth as a result of vasodilation (at low serum levels)
 - b) Pulse rate may decrease (bradycardia), eventually leading to heart block (with increasing levels)
 - d. Diagnostic data
 - 1) Serum magnesium level: increased above 3.0 mg/dL
 - 2) ECG: prolonged PR, QT, and QRS intervals; heart block and cardiac arrest with severely increased levels
 - e. Treatment (dependent on severity of imbalance)
 - 1) Prevention is the key
 - 2) Elimination of the cause
 - 3) Calcium gluconate given intravenously as a temporary measure to antagonize the action of the magnesium for more severe excesses
 - 4) With renal impairment, dialysis may be the only method to eliminate the excessive magnesium ions
 - f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor serum magnesium levels
 - 3) Have equipment readily accessible to assist respirations
 - 4) Provide patient teaching, including cautions about the use of over-the-counter magnesium-containing medications

E. Phosphate (HPO_4^-)

1. Overview
 - a. Located in the intracellular and extracellular compartments; only a small amount is located in the intracellular compartment
 - b. Major anion in the ICF, primarily found in the bones and teeth
 - c. Ability to shift between compartments; usually present in the body in the form of phosphate (the two terms phosphorus and phosphate are frequently used interchangeably)
 - d. Metabolism and homeostasis of phosphates are related to calcium metabolism
 - 1) Concentrations of both are controlled by the parathyroid gland
 - 2) Vitamin D is necessary for their absorption from the gastrointestinal tract
 - 3) Inverse proportional relationship with calcium
 - e. Important physiologic functions
 - 1) Metabolism of carbohydrates, fats, and protein
 - 2) Transfer of energy; phosphate is essential to all cells
 - 3) Necessary in formation of high-energy compounds ATP and adenosine diphosphate
 - 4) Maintenance of acid–base balance (primary urinary buffer)
 - 5) Promotion of muscle and nerve activity
 - 6) Delivery of oxygen; functions in the formation of red blood cell enzyme
 - f. Normal serum phosphate level: 2.7 to 4.5 mg/dL
2. Hypophosphatemia
 - a. Definition
 - 1) Phosphate deficit
 - 2) Serum level below 2.7 mg/dL
 - b. Etiology
 - 1) Transient intracellular shifts (phosphate movement into cells)
 - a) Administration of high concentrations of glucose without phosphorus
 - b) Increased intracellular pH (as occurs in respiratory alkalosis)
 - 2) Increased losses
 - a) Diuretics (thiazides)
 - b) Diabetic ketoacidosis
 - c) Hypokalemia
 - d) Hyperparathyroidism
 - e) Hypomagnesemia
 - f) Burns
 - 3) Reduced intestinal absorption
 - a) Antacid use
 - b) Vomiting
 - c) Diarrhea
 - d) Malabsorption syndromes
 - e) Alcoholism
 - f) Overzealous refeeding; parenteral nutrition without adequate phosphate
 - c. Signs and symptoms
 - 1) Neurological
 - a) Fatigue
 - b) Confusion

- c) Paresthesias
 - d) Seizures
 - e) Nystagmus
 - f) Numbness
 - g) Coma
- 2) Cardiovascular
 - a) Dysrhythmias
 - b) Decreased contractility
- 3) Muscle weakness
- 4) Respiratory muscle weakness may lead to respiratory failure
- 5) Altered red blood cell make-up and the ability of red and white blood cells to function
- d. Diagnostic data
 - 1) Serum phosphate level: low
 - 2) Serum magnesium and potassium levels: low
 - 3) Parathyroid hormone level: elevated if deficit is caused by hyperparathyroidism
 - 4) Radiography: skeletal changes of osteomalacia or rickets
- e. Treatment
 - 1) Prevention through education regarding proper use of antacids
 - 2) Oral supplements for mild-to-moderate losses
 - 3) Intravenous administration of phosphate is necessary for more severe deficits
 - a) Sodium phosphate
 - b) Potassium phosphate
- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor laboratory tests
 - 3) Take appropriate actions, such as seizure precautions
 - 4) Monitor the infusion site when potassium phosphate is used; infiltrations may lead to necrosis and sloughing of affected tissue
 - 5) Observe for possible hypocalcemia as the phosphate deficit is corrected
 - 6) Observe for cardiac, GI, and neurologic abnormalities
 - 7) Keep accurate intake and output records
 - 8) Monitor for refeeding syndrome once oral feeding is restarted after prolonged starvation
- 3. Hyperphosphatemia
 - a. Definition
 - 1) Phosphate excess
 - 2) Serum level above 4.5 mg/dL
 - b. Etiology
 - 1) Renal disease (a major cause; acute and chronic renal failure) decreases the kidney's ability to excrete phosphate
 - 2) Increased intake
 - a) Oral intake
 - b) Gastrointestinal absorption is related to vitamin D excess
 - c) Phosphorus-containing enemas and laxatives
 - 3) Compartmental shifting
 - a) Respiratory acidosis and decreased cell utilization
 - b) Cellular breakdown such as with cytotoxic medications

- c. Signs and symptoms
 - 1) Signs and symptoms are relatively nonexistent
 - 2) Those present are a result of the reciprocal action of phosphate and calcium
 - 3) Indicators are usually related to a calcium deficit
 - a) Neuromuscular symptoms, including tetany and hyperactive reflexes
 - b) Soft tissue calcification with calcium phosphate deposits in the lungs, kidneys, heart, and corneas; deposits may interrupt normal function of the affected organ or area with site-specific signs and symptoms
- d. Diagnostic data
 - 1) Serum phosphate level: elevated above 4.5 mg/dL (2.6 mEq/L)
 - 2) Serum calcium level: decreased; useful in assessing the potential consequences of the treatment
 - 3) Serum creatinine level: elevated if the cause is thought to be connected to renal disease
 - 4) Serum PTH: decreased in those with hypoparathyroidism
 - 5) Radiography: skeletal changes of osteodystrophy
- e. Treatment
 - 1) Prevention is the key
 - 2) Restriction of dietary intake
 - 3) Phosphate-binding gels or antacids are used to help increase intestinal elimination of excessive phosphate
 - 4) Hemodialysis possible in severe cases, particularly with renal involvement
 - 5) Cause related to neoplastic disease
 - a) Maintenance of fluid balance
 - b) Treat electrolyte imbalances (hyperkalemia, hypocalcemia, hyperuricemia, and hyperphosphatemia)
 - c) Hemodialysis or peritoneal dialysis (renal failure)
- f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor serum phosphate levels

F. Chloride (Cl⁻)

- 1. Overview
 - a. Primary anion in the ECF
 - b. Important physiologic functions
 - 1) Regulation of serum osmolality
 - 2) Regulation of acid–base balance
 - 3) Regulation of fluid balance when sodium is retained and chloride is also retained
 - 4) Control of acidity of gastric secretions
 - 5) Role in oxygen–carbon dioxide exchange (chloride shift)
 - c. Direct relationship with sodium and potassium
 - 1) With increased levels of sodium or potassium, chloride level also increases
 - 2) Inverse proportional relationship with bicarbonate
 - d. Filtered out of the ECF by the kidney glomeruli
 - e. Amount needed to maintain balance is reabsorbed by the renal tubules
 - f. Normal serum chloride level: 95 to 108 mEq/L

2. Hypochloremia
 - a. Definition
 - 1) Chloride deficit
 - 2) Serum level below 95 mEq/L
 - b. Etiology
 - 1) Generally associated with sodium and potassium deficits
 - 2) A loss of gastric juices or prolonged vomiting may result in hypochloremic alkalosis
 - 3) Possible decreased renal chloride reabsorption
 - c. Signs and symptoms
 - 1) Usually related to the attached cation (sodium or potassium)
 - d. Diagnostic data
 - 1) Serum chloride level: decreased below 95 mEq/L
 - 2) Serum sodium and potassium levels: decreased
 - 3) ABGs: alkalosis possible
 - e. Treatment
 - 1) Eliminate the cause
 - 2) Electrolyte replacement
 - 3) Replacement for severe deficits is dependent on the status of the other electrolytes
 - 4) Intravenous sodium chloride or potassium chloride solutions may be indicated
 - f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor serum chloride levels
3. Hyperchloremia
 - a. Definition
 - 1) Chloride excess
 - 2) Serum levels above 108 mEq/L
 - b. Etiology
 - 1) Increased intake from continuous or excessive intravenous administration of potassium- or sodium-containing solutions (particularly hypertonic sodium chloride solutions)
 - 2) Metabolic acidosis as a result of an excessive loss of bicarbonate or dehydration
 - c. Signs and symptoms
 - 1) Similar to those associated with the excessive cation
 - d. Diagnostic data
 - 1) Serum chloride level: increased
 - 2) ABGs: acidosis
 - 3) Renal function tests: reflective of renal disease
 - 4) Serum sodium or potassium levels: may be elevated (because chloride is usually associated with these electrolytes)
 - e. Treatment
 - 1) Eliminate the cause
 - 2) Monitor signs and symptoms
 - 3) Decrease the cation level with subsequent decrease in loss of chloride if the excess is related to an increased cation level
 - f. Nursing interventions
 - 1) Assess patient for clinical signs and symptoms
 - 2) Monitor serum chloride level



V. Acid–Base Balance and Imbalance

A. Overview

1. Acid–base balance is necessary to maintain homeostasis
2. Acids are substances that give up hydrogen ions
3. Bases accept hydrogen ions
4. Acid–base balance is regulated through the chemical buffering system, the kidneys, and the lungs
 - a. These buffers are present in all body fluids, tissue, and bone
 - b. Bicarbonate–carbonic acid is the major extracellular buffer
 - c. Intracellular buffers include organic and inorganic phosphates, proteins, and hemoglobin
5. The renal system helps to maintain balance through the reabsorption and regeneration of bicarbonate and the secretion of hydrogen
6. The lungs regulate carbon dioxide by adjusting the rate and depth of ventilation
7. Acid–base imbalances may be classified as metabolic or respiratory and further subdivided as acidosis or alkalosis
8. Acid–base balance is determined through the use of ABGs
 - a. The pH measures the hydrogen ion (H^+) concentration
 - b. The $PaCO_2$ is the respiratory component of the acid–base balance and is related to the partial pressure of CO_2 in arterial blood
 - c. Bicarbonate is the major extracellular buffer
 - d. The PaO_2 is the partial pressure of arterial oxygen
 - e. The normal values include
 - 1) pH: 7.35 to 7.45
 - 2) Partial pressure of arterial blood ($PaCO_2$): 35 to 40 mm Hg
 - 3) Bicarbonate (HCO_3): 22 to 31 mEq/L
 - 4) Partial pressure of O_2 in arterial blood (PaO_2): 80 to 100 mm Hg

B. Metabolic Acidosis

1. Description
 - a. Related to an increase in metabolic acids that exceeds the amount of bicarbonate
 - b. Factors that can lead to metabolic acidosis
 - 1) Chloride, as well as bicarbonate, may compete to bind with sodium
 - 2) Loss of bicarbonate through the renal system or an inability to generate new bicarbonate
 - 3) Loss of bicarbonate through the gastrointestinal system
 - 4) Decreased oxygen to the cells
 - c. Imbalance may be chronic or acute
 - 1) Chronic imbalance is usually related to chronic renal disease; correction is usually not required for adults
 - 2) Acute metabolic acidosis
 - a) Generally occurs from bicarbonate losses caused by diarrhea or increased renal excretion
 - b) May be caused by an excessive amount of hydrogen ions attributable to decreased renal excretion, increased production, lactic acidosis, ketoacidosis, or excessive ingestion of acids such as methanol or salicylates

2. Signs and symptoms (usually directly related to the cause)
 - a. Increased rate and depth of respirations
 - b. Decreased blood pressure
 - c. Headaches
 - d. Weakness
 - e. Confusion
 - f. Nausea
 - g. Vomiting
 - h. Cardiac response becomes limited, leading to vasodilation exhibited as warm, dry, and flushed skin (in severe cases)
3. Diagnostic data
 - a. pH: <7.35
 - b. Bicarbonate level: <22 mEq/L
 - c. Urine pH: acidic (with normal renal function)
 - d. Serum potassium level: frequently increased
4. Treatment (correct the cause)
 - a. Establish vascular access because very low arterial pH levels could be life-threatening
 - b. Administration of sodium bicarbonate and potassium
 - 1) Add to a parenteral solution
 - 2) Administer by intravenous drip
 - 3) Sodium bicarbonate may be given by intravenous push for cardiac arrest
5. Nursing interventions
 - a. Monitor related signs and symptoms and diagnostic findings
 - b. Monitor for fluid overload with dilution or depletion of electrolytes
 - c. Monitor hematocrit and plasma proteins
 - d. Monitor for alkalosis as it may result from overcorrection of acidosis

C. Metabolic Alkalosis

1. Description
 - a. Results from an excess of sodium bicarbonate caused by a bicarbonate gain or a hydrogen ion loss
 - b. Acute
 - 1) Primarily from hydrogen ion, extracellular volume, and potassium chloride depletion
 - a) Vomiting
 - b) Gastric suctioning
 - c) Diuretics
 - 2) Signs and symptoms (generally related to hypovolemia and hypokalemia)
 - a) Hyperactive reflexes
 - b) Mental confusion
 - c) Depressed respirations
 - d) Tetany from decreased calcium levels
 - e) Cardiac dysfunction from hypokalemia
 - 3) Diagnostic data (acute and chronic)
 - a) Arterial bicarbonate level: elevated (>31 mEq/L)
 - b) pH level: exceeding 7.45
 - c) Sodium, potassium, and phosphorus levels: underlying cause may reveal deficits

- d) Calcium level: increased or decreased
- e) ECG: reveals an increased heart rate and prolonged QT intervals
- 4) Treatment (varies with underlying cause)
 - a) No treatment necessary unless imbalance is severe
 - b) 0.9% or 0.45% sodium chloride solutions for more severe imbalances resulting from gastric and urinary losses
 - c) Potassium chloride when alkalosis is related to hypokalemia
 - d) Acidifying agents, histamine H_2 receptor antagonists, and acetazolamide (Diamox) are used
- 5) Nursing interventions (acute and chronic)
 - a) Monitor signs and symptoms and laboratory data
- c. Chronic
 - 1) Results when acute form is not corrected
 - a) Long-term diuretic therapy (thiazides, furosemide); hydrogen ion loss
 - b) Excretion of bicarbonate related to mineralocorticoid effect
 - 2) Shift of hydrogen ions into cells is caused by hypokalemia, bicarbonate retention, and administration of excess parenteral alkaloid solutions
 - 3) Signs and symptoms
 - a) Few to none
 - b) Possible manifestations of potassium depletion
 - 4) Diagnostic data: see acute metabolic alkalosis
 - 5) Treatment (related to negating the underlying cause)
 - a) 0.9% sodium chloride solutions for correction of volume depletion (often unsuccessful in correcting chronic alkalosis)
 - b) Oral or intravenous potassium chloride administration (most often successful)
 - c) Diuretics (acetazolamide [Diamox], potassium-sparing)
 - 6) Nursing interventions: see acute metabolic alkalosis

D. Respiratory Acidosis

- 1. Description
 - a. Inability of the lungs to eliminate carbon dioxide equal to the amount produced
 - b. Level is controlled through the rate and depth of respirations
 - c. Imbalance can be acute or chronic
 - d. Acute respiratory acidosis is related to inability to control rate and depth of respirations
 - 1) Medications (sedatives)
 - 2) Cerebral injury (cardiac arrest)
 - 3) Disease (pneumonia)
 - e. Chronic respiratory acidosis occurs when the amount of carbon dioxide produced exceeds the amount eliminated for an extended period of time
 - 1) Emphysema
 - 2) Cystic fibrosis
 - 3) Bronchial asthma
- 2. Signs and symptoms
 - a. Usually directly related to the cause, not the acidosis
 - b. Often as a result of the effects on the central nervous system
 - 1) Restlessness
 - 2) Confusion

- 3) Nausea
- 4) Vomiting
- 5) Muscular twitching
- 6) Convulsions
- c. Cardiac
 - 1) Increased pulse and respiratory rates
 - 2) Increased blood pressure
 - 3) Warm, flushed skin
 - 4) Weakness, with a dull headache when the arterial baseline level increases rapidly
- 3. Diagnostic data
 - a. Serum pH: <7.35
 - b. PaCO_2 level: >42 mm Hg
- 4. Treatment
 - a. Correction of the underlying cause
 - b. Restoration of the carbon dioxide level
 - 1) Oxygen therapy
 - 2) Intubation and mechanical ventilation
 - 3) Bronchodilators and antibiotics if indicated (chronic form)
 - 4) Avoidance of narcotics and sedatives unless patient is intubated and mechanically ventilated (because of respiratory depression associated with the chronic form)
- 5. Nursing interventions
 - a. Monitor related signs and symptoms and diagnostic findings

E. Respiratory Alkalosis

- 1. Description
 - a. Result of increased ventilation
 - b. More carbon dioxide is eliminated than produced (hyperventilation)
 - 1) Hypoxemia
 - 2) High fever
 - 3) Excessive mechanical ventilation
 - 4) Salicylate intoxication
- 2. Signs and symptoms
 - a. Light-headedness
 - b. Tinnitus
 - c. Sweating
 - d. Increased respiratory rate and depth
 - e. Numbness and tingling of extremities
- 3. Diagnostic data
 - a. Serum pH: >7.35
 - b. PaCO_2 level: lower than 35 mm Hg
- 4. Treatment (directly related to correcting the underlying cause)
 - a. Oxygen therapy if hypoxemia is the causative factor
 - b. Rebreathing CO_2 therapy in severe cases
 - c. Reassurance to help the patient gain control and slow respirations (if caused by anxiety)
 - d. Sedative or tranquilizer for anxiety-related respiratory alkalosis
- 5. Nursing interventions
 - a. Monitor related signs and symptoms and diagnostic findings



VI. Parenteral Solutions

A. Overview

1. Crystalloid solutions
 - a. Capable of crystallization and are solutes that when placed in a solution mix with and dissolve into a solution
 - b. Considered true solutions that diffuse through membranes
 - c. Must be given three to four times the volume to expand the vascular space to the degree that the colloid solution achieves
 - d. Types of crystalloid solutions: dextrose, sodium chloride, balanced electrolyte solutions, and alkalizing solutions
2. Colloid solutions
 - a. Contain protein and starch molecules that remain distributed in the ECF space and do not form a true solution
 - b. Referred to as plasma expanders
 - c. Do not flow freely between fluid compartments
 - d. Increase intravascular colloid osmotic pressure
 - e. Most common colloid solutions include dextran, albumin, hetastarch, mannitol, and gelatin
3. Osmotic activity
 - a. Osmotic activity of a solution may be expressed in terms of either its osmolarity or tonicity
 - b. Osmolarity refers to the osmolar concentration in 1 L of solution
 - c. Tonicity refers to the tension or effect that the osmotic pressure of a solution with impermeable solutes exerts on cell size because of water movement across the cell
 - d. Intravenous solutions are classified as isotonic (or iso-osmolar), hypotonic, or hypertonic
 - 1) Isotonic solutions
 - a) Have the same tonicity as plasma, with an osmolarity ranging from 240 to 340 mOsm/kg
 - b) The osmotic pressure is the same within the intracellular and extracellular compartments
 - c) Water does not have the tendency to shift from one compartment to the other
 - d) Examples: 0.9% sodium chloride, 5% dextrose in water, and lactated Ringer's solution
 - 2) Hypotonic solutions
 - a) Have fewer particles, with an osmolarity of <240 mOsm/kg
 - b) Have a lower osmolarity than that of body fluids
 - c) Depending on the degree of hypotonicity, the volume of the fluid being pulled into the blood cells may cause them to swell and burst
 - d) When used, move water from the intravascular space into the intracellular compartment
 - e) Example: 0.45% sodium chloride
 - f) During administration of hypotonic solutions, patients require close monitoring
 - g) Sterile water is never used without additives because it is hypertonic

- 3) Hypertonic solutions
 - a) Have an osmolarity >340 mOsm/kg
 - b) Have a greater number of particles and exert more osmotic pressure than do normal body fluids
 - c) When used, fluid is pulled into the vascular system and may cause the cells to shrink depending on the hyperosmolar property of the solution
 - d) Examples: 5% dextrose in lactated Ringer's and 5% dextrose in 0.9% sodium chloride
 - e) Patients require close monitoring while receiving hypertonic solutions to prevent fluid overload

B. Selection Parameters

1. Patient assessment
 - a. Type and amount of fluid/electrolyte losses
 - b. Activity level
 - c. Clinical status
2. Type of the solution
 - a. A hypertonic solution may be the best choice to decrease ICF volume or for volume expansion
 - b. An isotonic solution may be needed to rapidly expand intravascular volume
 - c. A hypotonic solution may be necessary to treat excess electrolyte imbalances
3. Electrolytes
 - a. Electrolyte balance is necessary to maintain homeostasis
 - b. Intravenous administration of electrolyte supplements may be required to replace abnormal losses
 - c. The need for replacement is determined by monitoring laboratory findings and clinical signs and symptoms
 - d. Electrolyte excess can create equal or even greater complications than electrolyte deficits
 - 1) Hypotonic solutions are used to dilute concentration
 - 2) Electrolyte solutions that have an antagonistic effect are used (e.g., calcium gluconate to treat hyperkalemia)
4. Activity: increased activity accelerates the use of calories and the loss of fluids and electrolytes
5. Clinical status
 - a. Continually monitoring the clinical status is necessary to determine the need to initiate or readjust intravenous fluid delivery
 - 1) Body weight
 - 2) Intake–output status
 - 3) Vital signs
 - 4) Skin turgor
 - 5) Diagnostic findings
 - 6) Central venous pressure
 - b. Disease states/conditions, such as renal and endocrine diseases, influence the fluid status and the need for fluid replacement
 - 1) Trauma, including burns and head injury, may increase the need for fluids and electrolytes
 - 2) Patients undergoing surgery have specific needs that require consideration

C. Crystalloid Solutions

1. Sodium chloride solutions
 - a. Description: many clinical uses, including treatment of shock, hyponatremia, use with blood transfusions, resuscitation in trauma situations, fluid challenges, metabolic alkalosis, hypercalcemia, and fluid replacement
 - b. Use solutions cautiously in patients with heart failure
 - c. Available in a variety of concentrations, 0.25%, 0.45%, 0.9%, 3%, and 5% are most common
 - d. 0.45% sodium chloride solution
 - 1) Hypotonic solution containing equal amounts of sodium and chloride (77 mEq/L) and free water
 - 2) Used to replace hypotonic fluid losses, sodium, and chloride
 - 3) No calories provided
 - 4) Dilution and depletion of electrolytes and calories possible with continuous infusion
 - e. 0.9% sodium chloride solution
 - 1) Isotonic solution containing equal amounts of sodium and chloride (154 mEq/L)
 - 2) Sodium and chloride replacement
 - 3) Only recommended solution for use with blood transfusions
 - 4) Treatment of metabolic alkalosis
 - 5) Diluent for medications
 - 6) Calories, other electrolytes, or free water are not provided
 - 7) Sodium excess, fluid volume overload, and depletion of calories and other electrolytes are possible with continuous or rapid administration
 - f. 3% and 5% sodium chloride solutions
 - 1) Hypertonic solutions containing equal amounts of sodium and chloride
 - 2) 3% solution contains 257 mEq/500 mL; and 5% solution contains 428 mEq/500 mL
 - 3) Replacement for severe sodium deficits
 - 4) Slow and careful administration is required to prevent fluid volume overload or pulmonary edema
2. Dextrose solutions
 - a. Description: carbohydrates can be administered by parenteral route as dextrose, fructose, or invert sugar; dextrose is the most commonly administered carbohydrate
 - 1) Available in concentrations of 2.5%, 5%, 10%, 20%, 30%, 40%, 50%, and 70%
 - 2) Water and calories are provided
 - b. 5% dextrose in water
 - 1) Provides 5 g dextrose/100 mL (170 calories/L)
 - 2) Metabolized quickly, leaving only the water for distribution as needed within the appropriate fluid compartment
 - 3) Contains no electrolytes
 - 4) Generally used for initial hydration or as a vehicle for administering medications
 - 5) Water excess or intoxication is possible with prolonged use
 - 6) Not used for blood administration; dextrose causes the red blood cells to hemolyze

- c. 10% dextrose in water
 - 1) Hypertonic solution
 - a) Contains 10 g dextrose/100 mL (240 calories/L)
 - b) Provides calories and free water
 - 2) The highest percent of dextrose solution given peripherally
 - 3) Electrolyte depletion is possible with continuous administration because electrolytes are not found in the solution
- d. Concentrated dextrose in water (20%, 40%, 50%, 60%, and 70% dextrose in water)
 - 1) Hypertonic solutions
 - 2) Major use as a source of calories
 - 3) Usually added to amino acid solutions administered via a central vascular access device to provide total nutrition
 - 4) With administration, possible tolerance to glucose is compromised by sepsis, stress, and hepatic and renal failure
 - 5) Some medications such as steroids or diuretics may affect glucose tolerance
 - 6) Hypertonic dextrose solutions, mainly 50%, are used to correct blood sugar levels related to hypoglycemia
 - 7) Complications may occur from the administration of hypertonic glucose solutions
 - a) Hyperglycemia (if given rapidly)
 - b) Subsequent osmotic diuresis
 - c) May result in loss of fluids and electrolytes, possibly leading to hyperosmolar coma
 - d) Sudden demand for increased insulin production (hyperinsulinism) from excessive amounts of hypertonic dextrose
 - e) Vein irritation, damage, and thrombosis may occur unless hypertonic solutions are diluted before peripheral administration
- 3. Dextrose/sodium chloride combination solutions
 - a. Description: solutions that contain dextrose and hypotonic saline provide more water than that is required for the excretion of salt and are useful as hydrating fluids
 - b. A variety of dextrose/sodium chloride solutions are available
 - 1) 5% dextrose in 0.225% sodium chloride (isotonic)
 - 2) 5% dextrose in 0.33% sodium chloride (hypertonic)
 - 3) 5% dextrose in 0.45% sodium chloride (hypertonic)
 - 4) 5% dextrose in 0.9% sodium chloride (hypertonic)
 - 5) 2.5% dextrose in 0.45% sodium chloride (isotonic)
 - 6) 10% dextrose in 0.225% sodium chloride (hypertonic)
 - 7) 10% dextrose in 0.45% sodium chloride (hypertonic)
 - 8) 10% dextrose in 0.9% sodium chloride (hypertonic)
 - c. Calories, free water, sodium, and chloride are provided with the amounts depending on the concentration of the particular fluid
 - d. Used to replace deficits in fluid volume because they contain free water
 - e. Calories are supplemented by dextrose; concentration is based on individual patient needs
 - f. Additional electrolytes are also provided; concentration selected is dependent on the patient's serum electrolyte levels
 - g. Complications include any of those discussed in the sections related to dextrose solutions and sodium chloride solutions

4. Balanced electrolyte solutions
 - a. Description: available as hypotonic, or isotonic maintenance and hypertonic replacement solutions
 - b. Lactated Ringer's is the most common balanced electrolyte solution
 - c. A variety of electrolyte combinations are available
 - 1) May or may not contain dextrose
 - 2) Vary slightly among different manufacturers
 - d. Patient history, signs and symptoms, and diagnostic findings determine the formulation needed
 - e. Ringer's injection
 - 1) Isotonic solution containing sodium, potassium, calcium, and chloride
 - 2) Content approximates the electrolyte content found in plasma
 - 3) Used to replace electrolytes
 - a) Provides a water source for hydration
 - b) Replaces ECF losses
 - 4) Complications may result from continuous administration of Ringer's solutions only
 - a) Although the solution contains several electrolytes, the volume of some is not adequate when intake or losses are abnormal
 - b) Rapid administration may lead to excessive amounts of electrolytes
 - c) With no calorie source, using only Ringer's injection may lead to caloric depletion
 - d) Excessive amounts may cause fluid overload and dilution of some or all the serum electrolytes
 - f. 5% dextrose in Ringer's injection
 - 1) Hypertonic solution provides electrolytes and calories
 - 2) Similar applications as for Ringer's injection with the ability to provide calories
 - 3) Complications similar to those associated with Ringer's injection
 - 4) Possible electrolyte depletion if no other source of intake or abnormal losses are present
 - 5) Depending on the patient's serum laboratory values, rapid or excessive administration may lead to abnormally high serum electrolyte levels
 - 6) Depending on the patient's serum laboratory values, an excessive volume may result in hypervolemia with possible dilution of serum electrolytes
 - 7) Caution required when administering dextrose-containing solutions to patients with diabetes mellitus
 - g. Lactated Ringer's injection
 - 1) Electrolyte content similar to that found in plasma
 - 2) Isotonic solution providing sodium, potassium, calcium, chloride, and lactate
 - 3) Lactate added as a buffer
 - 4) Lactate metabolized to produce bicarbonate normally found in the ECF
 - 5) Used to treat hypovolemia and provide electrolytes
 - 6) With little or no intake or abnormal losses, inadequate electrolyte content is provided for maintenance therapy
 - 7) Complications include overhydration, electrolyte excess, electrolyte dilution, caloric depletion, and a magnesium deficit
 - 8) Metabolic alkalosis from excessive volume

- 9) Contraindicated in hepatic disorders because lactate is metabolized by the liver
- 10) Not used when lactic acidosis is present because of the possible overload of the buffering system
- h. 5% dextrose in lactated Ringer's
 - 1) Hypertonic solution
 - 2) Similar to lactated Ringer's solution, plus calories are provided
 - 3) Uses and complications are similar to those for lactated Ringer's
- i. Other electrolyte solutions
 - 1) A large number of specialty electrolyte solutions are available, with some containing dextrose
 - 2) Mostly isotonic until dextrose is added, and then hypertonic
 - 3) Uses determined by patient history, clinical signs and symptoms, and laboratory findings
 - 4) Precautions and complications are dependent on the fluid content and flow rate

D. Colloid Solutions

- 1. Description
 - a. Colloid solutions are plasma expanders
 - b. Act osmotically to expand the intravascular space
 - c. Do not expand the intracellular or interstitial spaces
 - d. Used to rapidly increase the intravascular volume in emergency situations
 - e. Include blood components and albumin and synthetic colloids such as dextran and mannitol
- 2. Dextran
 - a. Plasma expander available in two forms, low molecular weight and high molecular weight
 - b. Dextran 6%, high molecular weight, is available in 5% dextrose and 0.9% sodium chloride solutions
 - 1) Increased volume dependent on the amount of solution administered and on pre-administration fluid status and renal status
 - 2) Maximum effect occurs approximately 1 hour after completion of administration; lasts for approximately 24 hours
 - 3) Used in the treatment of shock or anticipated shock related to trauma, burns, or hemorrhage
 - 4) Not a substitute for blood or blood products
 - 5) May be used on short notice when time does not allow for blood type and cross match to be done
 - 6) Complications
 - a) Severe anaphylactoid reactions
 - b) Wheezing
 - c) Tightness in chest
 - d) Gastrointestinal disturbances
 - 7) Blood samples for typing and cross matching are drawn before administering dextran because of possible interference with laboratory testing
 - 8) Fluid overload possible
 - a) Lowered hematocrit
 - b) Decreased plasma protein levels
 - c) Diluted serum electrolyte levels

- 9) Contraindicated in patients with renal disease, congestive heart failure, bleeding disorders, or known dextran hypersensitivity
- c. Dextran 10%, low molecular weight, is available in 5% dextrose and 0.9% sodium chloride solutions
 - 1) Maximum volume expansion occurs shortly after completion of administration
 - 2) Excreted by renal system within 24 hours
 - 3) Volume expansion is relative to volume delivered, pre-existing fluid status, and excretion rate
 - 4) May be used to treat shock related to vascular volume loss
 - a) Burns
 - b) Surgery
 - c) Hemorrhage
 - d) Trauma
 - 5) May be used prophylactically to help prevent venous thrombosis and pulmonary embolism during surgical procedures
 - 6) Complications
 - a) Anaphylactoid reactions
 - b) Dilution of electrolytes
 - c) Circulatory overload with possible hematocrit and plasma protein dilution
 - d) Increased bleeding time
 - 7) Blood samples are drawn before giving this solution to eliminate any interference with laboratory testing
 - a) Blood cross match when proteolytic enzyme techniques are used
 - b) Bilirubin assays when alcohol is used
 - c) Total protein assays when biuret reagent is used
- 3. Mannitol
 - a. A sugar alcohol substance is available in a variety of concentrations from 5% to 25%
 - b. Osmotic pull of fluid into the intravascular space is created
 - c. Majority of the fluid is excreted by the kidneys within 3 hours
 - d. Used to promote fluid loss
 - 1) Diuresis in the oliguria phase of acute renal failure
 - 2) Excretion of toxic substances
 - 3) Treatment of intracranial pressure and cerebral edema
 - 4) Reduction of cerebrospinal fluid and intraocular pressure
 - e. Complications
 - 1) Fluid and electrolyte imbalances
 - 2) Fluid overload
 - 3) Cellular dehydration
 - 4) Nervous system toxicity
 - 5) Extravasation leading to skin irritation and tissue necrosis
 - f. When administering concentrated solutions, such as 20%, a filter must be used as there is a potential for crystal formation
- 4. Hetastarch (Hespan)
 - a. Synthetic polymer with colloidal properties similar to those of albumin
 - b. Available as a 6% concentration in 0.9% sodium chloride solution
 - c. Fluids are pulled from the cells into the intravascular space
 - d. Maximum volume is reached shortly after the completion of the infusion

- e. Volume and duration are dependent on the volume delivered, preadministration fluid status, and renal function
 - f. Used for fluid replacement in the treatment of shock related to a decreased intravascular volume
 - 1) Trauma
 - 2) Burns
 - 3) Hemorrhage
 - 4) Surgery
 - g. Complications
 - 1) Anaphylactoid reactions
 - 2) Increased bleeding times
 - 3) Altered platelet function
 - 4) Fluid volume overload
 - 5) Electrolyte and fluid imbalances
 - 6) Decreased hematocrit and plasma protein from increased fluid volume
5. Albumin
- a. Natural plasma protein prepared from human blood and blood-related products
 - b. Available in 5% and 25% concentrations
 - c. Osmotic pressure allows fluid to be pulled into the intravascular space, increasing the fluid volume and possibly the plasma protein volume
 - d. 5% solution is isotonic; 25% solution is hypertonic
 - e. Used for volume expansion in treating shock or impending shock related to circulatory volume deficit
 - f. Used for providing protein or for its ability to bind bilirubin
 - g. Complications
 - 1) Fluid volume overload
 - 2) Anemia
 - 3) Increased bleeding
 - 4) Dilution or depletion of electrolytes
 - 5) Allergic reactions
 - 6) Decreased hematocrit and plasma protein levels from increased fluid volumes
 - 7) Altered laboratory findings possible

E. Miscellaneous Solutions

- 1. Alkalinizing solutions: 5% sodium bicarbonate
 - a. Neutralize excess acids and restore homeostasis
 - b. Dissociates to provide the bicarbonate ion, the principal buffer in the ECF
 - c. Maintains osmotic pressure and acid–base balance
 - d. Used to treat metabolic acidosis and severe hyperkalemia
 - e. Complications
 - 1) Metabolic alkalosis
 - 2) Hypocalcemia
 - 3) Hypokalemia
 - 4) Sodium retention
 - 5) Hypervolemia, which may result in electrolyte imbalances
 - 6) Extravasation, possibly resulting in chemical cellulitis, necrosis, ulceration, or sloughing

2. Premixed solutions
 - a. Wide variety of premixed large-volume intravenous solutions and medications available
 - b. Greater assurance that the proper medication, diluent, base solution, and pH of the solution have been used
 - c. Longer expiration dating as a result of the sterilization process being completed after the admixture procedure
 - d. General disadvantages
 - 1) Potential increased costs
 - 2) Accidental delivery of a medication not ordered
 - 3) Incorrect dose when several concentrations of the same medication stocked
 - e. Potential complications are related to the individual solution and medication; viewed on an individual basis before administration



VII. Disease States and Conditions Affecting Fluid and Electrolyte Balance

A. Gastrointestinal System

1. Plays an important role in maintaining fluid and electrolyte balance
2. Loss of upper gastrointestinal contents by vomiting or gastric suctioning can cause
 - a. Hypovolemia due to abnormal fluid loss
 - b. Hyponatremia due to loss of sodium-rich fluids
 - c. Hypokalemia due to loss of potassium-containing fluids and inadequate replacement
 - d. Hypomagnesemia due to prolonged loss of upper GI fluids and inadequate replacement
 - e. Metabolic alkalosis due to loss of fluids rich in chloride and hydrogen
3. Loss of lower gastrointestinal contents (pancreatic juice, bile, intestinal secretions) due to diarrhea or bowel obstruction can cause
 - a. Hypovolemia due to abnormal fluid loss
 - b. Hyponatremia due to loss of sodium-containing fluids, thirst, or ADH-induced retention of water
 - c. Hypokalemia due to loss of potassium without adequate replacement
 - d. Metabolic acidosis due to loss of fluids rich in bicarbonate

B. Cardiac System

1. Helps in the control of fluids and electrolytes
 - a. Brain natriuretic peptide (BNP) is secreted in response to ventricular volume expansion and pressure, which signals acute heart failure
 - b. BNP regulates BP, electrolyte balance, and fluid volume
2. The heart is affected by fluids and electrolytes
 - a. Regulation of fluids and electrolytes is dependent on the heart pumping blood through the kidneys
 - b. Fluid volume is controlled by stretch receptors located in the heart and blood vessels
 - 1) FVD causes weak, rapid pulse
 - 2) FVE leads to bounding, full pulse

3. Potassium affects impulse conduction and contractibility
4. Sodium influences the cardiovascular system by causing changes in blood volume
5. Calcium helps to regulate contraction and relaxation of the heart muscle
6. Magnesium produces vasodilation
 - a. May lead to a drop in blood pressure and possibly precipitate cardiac arrest
 - b. Imbalances may lead to cardiac arrhythmias, hypotension, increased possibility of digoxin toxicity with magnesium deficit, and arrhythmias, vasodilation, and bradycardia with excessive magnesium levels

C. Renal System

1. The kidneys play a major role in maintaining fluid and electrolyte balance by excreting or retaining water, electrolytes, and organic materials
2. The renin-angiotensin-aldosterone system exerts its action through angiotensin II and aldosterone. Renin is an enzyme released by the kidney in response to changes in arterial pressure glomerular filtration rate and amount of sodium in the tubular fluid
3. Thirst, hormones, and the heart and blood vessels affect renal function
 - a. The hypothalamus manufactures ADH, which is stored in the posterior pituitary
 - b. When released, ADH causes the kidney tubules to reabsorb more water from the distal renal tubule and collecting duct
4. Laboratory tests, such as BUN and creatinine levels, are used to evaluate the renal system
5. Improper functioning of the renal system may lead to acute or chronic renal failure
6. Potassium is one of the major electrolytes excreted by the kidneys; any malfunction of the kidneys will affect the balance

D. Endocrine System

1. Plays a major role in regulating fluids and electrolytes
2. ADH is secreted by the hypothalamus and stored in the posterior pituitary
3. SIADH results in water retention and hyponatremia
 - a. Correction of the underlying cause and the elimination of excessive water retention
 - b. Close monitoring of sodium and fluid levels
4. The thyroid and parathyroid glands secrete hormones that affect calcium, magnesium, and phosphorus levels
5. There are two forms of diabetes: diabetes insipidus and diabetes mellitus
 - a. Diabetes insipidus is a disorder related to water imbalance as a result of a lack of ADH or failure of the kidney to respond to ADH
 - 1) May be caused by head trauma or metastatic tumors
 - 2) Clinical indicators include intense thirst, polyuria, increased serum sodium, and increased serum osmolality
 - 3) Treatment involves replacing the ADH and use of intravenous fluids and electrolytes
 - b. Diabetes mellitus results from a reduced secretion or utilization of insulin
 - 1) Hyperglycemia and diabetic ketoacidosis may result; evident by high blood glucose levels and high urine glucose readings

- 2) Imbalances related to diabetes mellitus include decreased serum carbon dioxide level, hypokalemia, and fluid volume level
- 3) Treatment may include insulin and fluid replacement
 - a) 0.9% sodium chloride
 - b) Lactated Ringer's injection
 - c) 0.45% sodium chloride
 - d) Electrolytes

E. Hepatic System

1. Normally, aldosterone is inactivated by the liver
2. An impaired liver is unable to carry out this function
 - a. Excess levels of aldosterone cause sodium to be retained, resulting in water retention
 - b. Other imbalances occur
 - 1) Hypokalemia
 - 2) Hyperkalemia (related to secondary kidney failure)
 - 3) Hypomagnesemia
 - 4) Hypocalcemia
 - 5) Hypophosphatemia
 - 6) Acid-base imbalances
 - c. Treatment is related to eliminating fluid excess and correcting electrolyte imbalances

F. Burns

1. Traumatizes the skin and allows loss of fluid and electrolytes
2. Severity of the imbalances is related to the depth of the burns and the percent of the body surface area affected
 - a. For the first 24 hours after more severe burns, intravascular water, proteins, and electrolytes are lost through the damaged capillaries and cells
 - b. After this period, the capillary walls start to seal and the compensatory changes begin
 - c. By the second or third day, the fluid causing the edema starts to shift from the interstitial space to the vascular space
 - 1) Blood volume increases
 - 2) Results in increased urinary output
3. Treatment includes the administration of intravenous solutions
 - a. Caution must be exercised to prevent fluid volume overload as the fluid shift occurs
 - b. Electrolyte levels must be monitored to ensure electrolyte balance, particularly potassium levels because of its loss from traumatized cells

G. Pregnancy-Induced Hypertension (Toxemia of Pregnancy)

1. Pregnancy has a great effect on fluid and electrolyte balance
 - a. Increased fluid volume
 - b. Changes in the renal function
 - c. Reduction in serum calcium
 - d. Alterations in the acid-base balance with respiratory alkalosis as a normal finding
2. Pregnancy-induced hypertension is characterized by edema, hypertension, proteinuria, and convulsions

3. When the condition becomes severe, magnesium sulfate may be used for its anticonvulsant effect
4. Serum magnesium levels must be monitored closely to prevent hypermagnesemia

BIBLIOGRAPHY

- Chernecky, C., & Berger, B. (2013). *Laboratory tests and diagnostic procedures* (6th ed.). St Louis, MO: Elsevier/Saunders.
- Gahart, B. L., & Nazareno, A. R. (2012). *2012 Intravenous medications* (28th ed.). St. Louis, MO: Mosby/Elsevier.
- Hankins, J. (2006). The role of albumin in fluid and electrolyte balance. *Journal of Infusion Nursing*, 29(5), 260–265.
- Hankins, J. (2010). Fluids and electrolytes. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 178–203). St. Louis, MO: Saunders/Elsevier.
- Heitz, U., & Horne, M. M. (2005). *Pocket guide to fluid, electrolyte and acid-base balance* (5th ed.). St. Louis, MO: C.V. Mosby.
- Infusion Nurses Society. (2011). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S1–S110.
- Kee, J. L., Paulanka, B. J., & Polek, C. (2008). *Fluids and electrolytes with clinical applications: A programmed approach* (8th ed.). Clifton Park, NY: Delmar Cengage Learning.
- McEvoy, G. K. (Ed.) (2012). *AHFS drug information 2012*. Bethesda, MD: American Society of Health-System Pharmacists.
- Pagana, K. D., & Pagana T. J. (2012). *Mosby's diagnostic and laboratory test reference* (11th ed.). St. Louis, MO: Mosby.
- Phillips, L. D. (2010a). Parenteral fluids. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 229–241) St. Louis, MO: Saunders/Elsevier.
- Phillips, L. D. (2010b). *Manual of I.V. therapeutics: Evidence-based practice for infusion therapy* (5th ed., pp. 105–186). Philadelphia, PA: F.A. Davis.
- Porth, C. M., & Matfin, G. (2010). Alterations in acid–base balance. In C. M. Porth & G. Matfin (Eds.), *Pathophysiology: Concepts of altered health states* (8th ed., pp. 693–734). Philadelphia, PA: Lippincott Williams & Wilkins.
- Smeltzer, S. C., Bare, B. G., Hinkel, J. L., & Cheever, K. H. (2010). Fluid and electrolytes: Balance and disturbances. In S. C. Smeltzer, B.G. Bare, J. L. Hinkel, & K. H. Cheever (Eds.), *Brunner & Suddarth's textbook of medical-surgical nursing* (12th ed., pp. 300–353). Philadelphia, PA: Lippincott, Williams & Wilkins.
- Wilkinson J. M., & Van Leuven, K. (2011). Fluids, electrolytes & acid–base balance. In J. M. Wilkinson & L. Treas (Eds.), *Fundamentals of nursing: Theory, concepts and applications* (2nd ed., pp. 887–898). Philadelphia, PA: F.A. Davis.

Pharmacology

Michelle S. Turner, PharmD, BCPS

Susan K. Poole, MS, BSN, RN, CRNI®, CNSN, CIC



I. Considerations for Intravenous Drug Administration

A. Nursing Responsibilities

1. Review the order for the appropriateness of prescribed therapy for the patient's age and condition, access device, dose, rate, and route of administration, and follow the rights of medication administration
2. Review facility policy for the list of approved parenteral medications and solutions for each type of administration method and route
3. Be knowledgeable of indications for therapy, side effects, potential adverse reactions, and appropriate interventions
4. Evaluate and monitor the effectiveness of prescribed therapy; document patient response, adverse events, and interventions; communicate laboratory tests results

B. Legal Considerations

1. State Nurse Practice Act determines the scope of practice for professional nursing within a given geographical area
2. Personal liability: each individual is responsible for his/her actions
3. Medication errors
 - a. Definition
 - 1) Is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer
 - 2) May be related to professional practice, healthcare products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use
 - b. Prevention—proactively looking at problem-prone areas of medication administration leads to reducing risks and preventing errors
 - c. Classification/reporting—understanding the type of error and reporting of near misses assist in the education process and identify common issues that lead to prevention

- d. Safety factors—advocate for the use of engineering controls, protocols, and technology that is intended and has been shown to reduce medication errors
 - 1) Electronic order entry
 - 2) Smart pumps with drug libraries
 - 3) Bar coding
 - 4) Procedures for distraction-free medication administration
 - 5) Establishment of protocols for high-risk intravenous drugs
 - 6) Standardized drug concentrations or standard order sets
- 4. Documentation
 - a. A record in written or printed form, containing original, official, or legal information
 - 1) Drug
 - 2) Dosage
 - 3) Rate of administration as given
 - 4) Time of actual administration
 - 5) Route of administration
 - 6) Patient's response to treatment
 - 7) Nurse's signature
 - b. Investigational drugs
 - 1) Know federal and state laws
 - 2) Review research protocol
 - 3) Obtain signed, informed consent
 - 4) Investigation protocols may be continued in alternative care settings if requirements met

C. Nursing Process

- 1. Patient assessment
 - a. Nursing history
 - 1) Sequence and length are modified consistent with the type of therapy ordered, acuity level of patient, and clinical setting in which care is delivered
 - 2) Health status: question patient concerning current health and health history, including disease-specific conditions, such as diabetes, cardiac disease, cirrhosis, and surgeries
 - 3) Allergies: specific to foods and drugs; other allergies and type of reaction and severity
 - 4) Medication history: for specific illness (e.g., diuretics, insulin, anticoagulants, aspirin, over-the-counter drugs, herbal products)
 - 5) Patient care plan: develops an individualized plan of care relative to medication administration
 - 6) Clinical assessment parameters
 - a) Age
 - b) Weight: such as percent loss in comparison with usual body weight and time span involved (30 days, 90 days)
 - c) Height
 - d) Body temperature
 - e) Skin
 - Tissue turgor
 - Appearance: skin should be dry and intact
 - Presence of rash or lesions
 - Presence of petechiae; absorption may be impeded with subcutaneous administration

- f) Edema
 - g) Other sources of fluid loss, such as fistulas, vomiting, diarrhea, and drains
 - h) Sensorium
 - i) Related therapies may affect the ability to maintain patency of the infusion line; for example, hydrotherapy may limit the use of hand veins for infusion purposes, and hyperbaric medicine may necessitate removal of a flush solution from an intermittent infusion device before treatment
2. Laboratory data
- a. Hematology
 - 1) Prothrombin time (PT)
 - 2) Partial thromboplastin time (PTT)
 - 3) Antithrombin III (heparin cofactor activity)
 - 4) Complete blood count (CBC)
 - b. Chemistry panel
 - 1) Comprehensive measurement of the body's chemical constituents found in the blood, including electrolytes, enzymes, hepatic and renal function, and blood sugar
 - 2) Blood urea nitrogen (BUN)
 - c. Urine
 - 1) Determines various properties of urine
 - 2) Analysis of drug excretion is often measured
 - d. Therapeutic drug monitoring
 - 1) Ensures appropriate dosing regimens so that the concentration of the drug is between the minimum level and the toxic level
 - 2) Required for patients
 - a) Receiving combination therapies
 - b) With renal dysfunction
 - c) With third spacing in whom therapeutic failure would prove catastrophic
 - d) Who fail to have anticipated response to therapy, despite appropriate dosing
 - 3) Blood levels
 - a) Peak: maximum drug concentration is achieved after administration of single dose
 - b) Trough: minimum drug concentration after administration of single dose
 - c) Sensitivities: a screen used in determining sensitivity or resistance of bacteria to specific drugs
 - d) Toxicology screens
3. Interventions
- a. Administer solutions and medications prepared and dispensed from the pharmacy or as commercially prepared solutions and medications whenever feasible
 - b. Medications admixed outside of the pharmacy, pharmacy-labeled solutions, and medications labeled for emergent use should be started within 1 hour of preparation
 - c. Trace the administration set from the patient to the point of origin before making connections and on admission or transfer of a patient to a new setting
 - d. Aspirate for a positive blood return from the vascular access device (VAD) to confirm device patency prior to administration of parenteral medications and solutions

4. Evaluation of response to treatment
 - a. Evaluate and monitor the effectiveness of prescribed therapy; documenting patient response, adverse events, and interventions
 - 1) Adverse reaction: an unwanted, unexpected, noxious, or potentially harmful reaction to a medication
 - b. Communicate to the licensed independent practitioner (LIP) and the patient care team the results of laboratory tests
 - c. Discontinue therapy when the nursing assessment determines that intervention is necessary (e.g., in the event of an adverse reaction, complication such as phlebitis or infiltration, suspected VAD malposition, or loss of VAD patency)
 - d. The LIP should be notified of the assessment and intervention immediately
5. Document discontinued therapy in the patient's permanent medical record therapy, including amount infused, time, date, condition of the site, integrity of the catheter if removed, and reason for discontinuation
6. Provide instruction to the patient and caregiver about the observations and care of the infusion and catheter site and potential postinfusion complications, such as postinfusion phlebitis or infiltration, and document such instructions in the patient's permanent medical record



II. Drug Administration

A. Drug Preparation

1. Parenteral solutions: know the tonicity (hypertonic, hypotonic, or isotonic) of the parenteral solution and whether it is appropriate for the prescribed route
2. Syringes
 - a. Use the appropriate size syringe for the volume of drug/solution to be withdrawn
 - b. Syringe-to-syringe transfer is not recommended due to the risk of serious medication errors
3. Needles
 - a. Select the appropriate size needle for withdrawing solution from a vial or ampoule
 - b. If available and appropriate for the medication, needleless vial adapters may be used
 - c. Multidose vial use should be avoided
 - d. Blunted filter needles or filter straws should be used when withdrawing medications from glass ampoules
4. Inspect solutions and medications
 - a. Appropriate labeling
 - b. Integrity (no leakage/discoloration/open packaging)
 - c. Accuracy (right drug or solution and right dose)
 - d. Sterility (within beyond-use or expiration date)
 - e. In the home care setting, verify appropriate storage/refrigeration

B. Drug Forms

1. Powders: require reconstitution
2. Liquids: in the appropriate liquid form
3. Premixed: drugs may be premixed with intravenous additives

C. Drug Containers

1. Vials include double-compartment, pump-action, and additive piggyback
 - a. Single-use vial: hermetically sealed with rubber stopper and intended for one-time use
 - b. Multiple-dose vial: hermetically sealed with rubber stopper and designed to be entered more than once
2. Ampoules: a hermetically sealed glass medication container in which the neck of the container must be broken to access the medication
3. Prefilled syringes: minimize errors in calculation and ensure drug preparation in the correct volume of diluent

D. Drug Compatibility and Stability

1. Compatibility
 - a. Capability of being mixed and administered without undergoing undesirable chemical or physical changes or loss of therapeutic action
 - b. Factors affecting compatibility
 - 1) Concentration of drug
 - 2) Length of time drugs are in contact with other additives or diluent
 - 3) pH of admixture
 - a) pH: symbol for degree of concentration of hydrogen ions or acidity of solution
 - 4) Presence of buffers
 - a) Addition of buffers may minimize the potential for the development of phlebitis
2. Incompatibilities
 - a. Chemical: a change, which may or may not be visually observed, in the molecular structure or pharmacologic properties of a substance (e.g., penicillin and ascorbic acid, lowering the pH)
 - b. Physical: an undesirable change that is physically observed (e.g., sodium bicarbonate and calcium chloride, forming an insoluble precipitate)
 - c. Therapeutic: an undesirable reaction resulting from the overlapping effects of two drugs given together or closely together (e.g., penicillin and tetracycline, inhibiting the bactericidal effect of penicillin)
3. Drug stability
 - a. The length of time the drug retains its original properties and characteristics
 - b. Factors affecting drug stability
 - 1) Parenteral solutions: tonicity may affect stability
 - 2) Additive drugs: presence may affect pH
 - 3) Buffers: used to stabilize the drug in solution
 - 4) Preservatives: to prolong shelf-life
 - 5) Time in solution: some drugs require admixing immediately before administration
 - 6) Order of mixing: end product may be affected
 - 7) Amount of diluent
 - 8) Light
 - 9) Temperature

E. Methods of IV Drug Administration

1. Bolus injection
2. IV drip (gravity) with or without flow control device
3. Infusion via mechanical (e.g., syringe pump, elastomeric) or electronic device

F. Drug Calculations

1. Drug dosage determination
 - a. Body surface area (BSA)
 - 1) Frequently used to calculate dosage
 - 2) Nomogram method: to calculate BSA, draw a straight line between the point representing patient's height on left vertical scale and the point representing patient's weight on right vertical scale. The point at which this line intersects the middle vertical scale represents the patient's surface area in square meters
 - b. Ratio-proportion method
 - 1) A ratio is a comparison between two related items, and a proportion is the equality of two ratios
 - 2) When setting up a proportion, start with what you know about the drug from the label; the strength of the drug on hand (H) and the volume of the drug on hand (V). Place this information in the form of a ratio (H:V) on the left of the equal sign (=). The ratio for the dose desired is the relationship of the dose ordered (D) and the amount to give (G), and this is placed on the right side of the equal sign (H:V = D:G)
 - 3) Thus, the strength on hand (H) is related (:) to the volume (V) as (=) the dose ordered (D) is related (:) to the amount to give (G)
 - 4) For an answer to be correct, the product of the means must equal the product of the extremes. The extremes are always the two outside numbers
 - c. Formula method
$$\text{Amount to give (G)} = \frac{\text{Dose ordered (D)}}{\text{Strength on hand (H)}} \times \text{Volume (V)}$$
2. Flow rate determination
 - a. Milliliter per hour: total volume (mL) ÷ administration time (hour)
= milliliters per hour (mL/hour)
 - 1) Milliliters per minute: milliliters per hour (mL/hour) ÷ minutes per hour (60) = milliliters per minutes (mL/minute)
 - 2) Macrodrop infusion formula:
 - a) 10, 15, or 20 drops (drops) per 1 mL
 - b) Milliliters per minute (mL/minute) × drops per milliliter (drops/mL)
= drops per minute (drops/minute)
 - 3) Microdrop infusion formula:
 - a) 60 drops (drops) per 1 mL
 - b) Milliliters per minute (mL/minute) × drops per milliliter (drops/mL)
= drops per minute (drops/minute)
 - b. Intermittent medication or solution calculation
 1. Volume to be infused (mL) ÷ mL/hour = number of hours
3. Medication conversions
 - a. Microgram/kilogram (mcg/kg)
 - 1) Kilogram × 1,000 = 1,000 grams
 - 2) 1 gram × 1,000 = 1,000 milligrams (mg)
 - 3) 1 milligram × 1,000 = 1,000 micrograms (mcg)

- b. Milligrams per minute (mg/minute)
 - 1) Determine the total amount of the drug in the solution
 - 2) Divide the drug amount (in milligrams) by the total volume in solution (mL) = concentration of the solution (mg/mL)
 - 3) Divide the desired amount of drug (in mg/minute) by the concentration of the solution (in mg/mL) = infusion rate (mL/minute)
 - 4) To convert to mL/hour: $\text{mL/minute} \times 60 \text{ minutes/hour} = \text{mL/hour}$
4. Percentage solutions
 - a. Percent solution is a measure of parts per hundred
 - b. 1% solution = 1 g of drug in 100 mL of solution



III. Drug Classifications

A. Anti-infective Agents

1. Natural penicillins
 - a. Prototype: penicillin G potassium/sodium (Pfizerpen)
 - b. Indications: used to treat infections with penicillin-sensitive organisms such as meningitis or endocarditis
 - c. Usual dosage: 2,000,000 to 5,000,000 units every 4 hours
 - d. Mode of administration: intermittent, continuous
 - e. Major side effects: fever, chills, edema, urticaria, rash
 - f. Nursing considerations: monitor electrolyte balance because of sodium or potassium base
 - g. Patient/caregiver education: instruct patient to report venous pain
2. Aminopenicillin
 - a. Prototype: ampicillin sodium (Omnipen-N)
 - b. Indications: respiratory, ear, gastrointestinal, genitourinary, and skin infections
 - c. Usual dosage: 1 to 2 g every 4 to 6 hours
 - d. Mode of administration: push, intermittent
 - e. Major side effects: dermatitis, rash, urticaria, anemia
 - f. Nursing considerations: stability is concentration-dependent and decreases as the concentration of the drug increases; the drug is especially susceptible to inactivation in dextrose solutions
 - g. Patient/caregiver education: instruct patient to report skin rash, previous sensitivities
 - h. Related drug: ampicillin sodium/sulbactam sodium (Unasyn)
3. Penicillinase-resistant penicillin
 - a. Prototype: nafcillin sodium (Unipen)
 - b. Indication: infection caused by penicillinase-producing staphylococci
 - c. Usual dosage: 1 to 2 g every 4 hours
 - d. Mode of administration: push, intermittent
 - e. Major side effects: rash, fever, and pruritus
 - f. Nursing considerations: monitor renal, hepatic, and hematopoietic functions; local reactions can occur such as pain, phlebitis, thrombophlebitis, and occasionally skin sloughing with extravasation
 - g. Patient/caregiver education: instruct patient to recognize and report adverse effects
 - h. Related drug: oxacillin sodium (Bactocil)

4. Extended-spectrum penicillin
 - a. Prototype: piperacillin sodium and tazobactam sodium (Zosyn)
 - b. Indications: respiratory, urinary, skin, bone, and joint infections
 - c. Usual dosage: 2.25 to 4.5 g every 6 hours
 - d. Mode of administration: intermittent
 - e. Major side effects: rash, fever, nausea, neutropenia, and pruritus
 - f. Nursing considerations: evaluate renal and hematopoietic systems
 - g. Patient/caregiver education: instruct patient to report skin rash
 - h. Related drug: ticarcillin disodium/clavulanate potassium (Timentin)
5. Cephalosporins
 - a. First-generation agent
 - 1) Prototype: cefazolin sodium (Kefzol, Ancef)
 - 2) Indications: perioperative prophylaxis; bone, joint, respiratory, genitourinary, or gastrointestinal infections
 - 3) Usual dosage: 500 mg to 2 g every 6 to 8 hours
 - 4) Mode of administration: push, intermittent
 - 5) Major side effects: urticaria, rash, nephrotoxicity, leukopenia, nausea, pain, and induration at site
 - 6) Nursing considerations: in a patient with a penicillin allergy, cefazolin may cause cross-sensitivity (similarity in chemical structure); monitor infusion site for pain and induration
 - 7) Patient/caregiver education: instruct patient in recognizing and reporting change at infusion site and flank pain
 - b. Second-generation agent
 - 1) Prototype: cefuroxime sodium (Zinacef)
 - 2) Indications: respiratory, urinary tract, and skin infections; sinusitis, bronchitis, pharyngitis, tonsillitis, otitis media
 - 3) Usual dosage: 750 mg to 1.5 g every 8 hours
 - 4) Mode of administration: push, intermittent
 - 5) Major side effects: leukopenia, neutropenia, vomiting, oral thrush, rash, and diarrhea
 - 6) Nursing considerations: may cause phlebitis; provide oral care
 - 7) Patient/caregiver education: instruct patient to report changes in bowel habits
 - 8) Related drugs: cefoxitin sodium (Mefoxin) and cefotetan disodium (Cefotan)
 - c. Third-generation agent
 - 1) Prototype: ceftriaxone sodium (Rocephin)
 - 2) Indications: meningitis, endocarditis; bone, joint, respiratory, intra-abdominal, genitourinary, and skin infections
 - 3) Usual dosage: 1 to 2 g every 12 to 24 hours
 - 4) Mode of administration: intermittent
 - 5) Major side effects: diarrhea, rash, and eosinophilia
 - 6) Nursing considerations: precipitation can occur when combined with solutions containing calcium (Ringer's lactate, parenteral nutrition)
 - 7) Patient/caregiver education: instruct patient to report any adverse effects
 - 8) Related drugs: cefotaxime sodium (Claforan) and ceftazidime (Fortaz)
 - d. Fourth-generation agent
 - 1) Prototype: cefepime hydrochloride (Maxipime)
 - 2) Indications: serious bacterial infections such as pneumonia or febrile neutropenia

- 3) Usual dosage: 0.5 to 2 g every 8 to 12 hours
- 4) Mode of administration: intermittent
- 5) Major side effects: rash, diarrhea, seizures, and pain at infusion site
- 6) Nursing considerations: monitor renal function
- 7) Patient/caregiver education: teach signs and symptoms of allergic reaction
- e. Fifth-generation agent
 - 1) Prototype: ceftaroline fosamil (Teflaro)
 - 2) Indications: pneumonia; skin and skin structure infections; treatment of infections due to methicillin-resistant *Staphylococcus aureus*
 - 3) Usual dosage: 600 mg every 12 hours
 - 4) Mode of administration: intermittent
 - 5) Major side effects: diarrhea, nausea, rash, colitis, infusion site reactions
 - 6) Nursing considerations: administer as a slow infusion over 60 minutes
 - 7) Patient/caregiver education: instruct patient to report adverse effects
6. Carbapenems
 - a. Prototype: imipenem and cilastatin (Primaxin)
 - b. Indications: respiratory, skin, bone, joint, intra-abdominal, and gynecologic infections
 - c. Usual dosage: 250 to 500 mg every 6 hours
 - d. Mode of administration: intermittent
 - e. Major side effects: nausea, diarrhea, colitis, seizures, rash, pruritis
 - f. Nursing considerations: monitor intake and output; reduce the rate of infusion if nausea develops; monitor infusion site
 - g. Patient/caregiver education: instruct patient to report decreased urine output
 - h. Related drugs: meropenem (Merrem), doripenem (Doribax), ertapenem sodium (Invanz)
7. Aminoglycosides
 - a. Prototype: gentamicin sulfate (Garamycin)
 - b. Indications: specific gram-negative infections; a combination treatment for gram-positive infections
 - c. Usual dosage: 1 to 1.5 mg/kg every 8 hours or 7 mg/kg every 24 hours
 - d. Mode of administration: intermittent
 - e. Major side effects: ototoxicity, nephrotoxicity, neuromuscular blockade, and rash
 - f. Nursing considerations: monitor BUN, serum creatinine, and peak/trough levels
 - g. Patient/caregiver education: instruct patient to report hearing difficulties, tinnitus, dizziness, and changes in urine output
 - h. Related drugs: tobramycin sulfate (Nebcin), amikacin sulfate (Amikin)
8. Tetracyclines
 - a. Prototype: doxycycline hyclate (Vibramycin IV)
 - b. Indications: broad-spectrum against gram-negative and gram-positive organisms; treatment of uncommon infectious diseases
 - c. Usual dosage: 200 mg loading dose, and then 100 mg every 12 hours
 - d. Mode of administration: intermittent
 - e. Major side effects: anorexia, diarrhea, skin rashes, blood dyscrasias, photosensitivity, and thrombophlebitis
 - f. Nursing considerations: phlebitis may occur because doxycycline is inhibited by alkalinizing agents, infuse slowly over 1 to 4 hours

- g. Patient/caregiver education: instruct patient to avoid exposure to sun when taking this medication and to recognize and report induration at the infusion site
 - h. Related drugs: minocycline (Minocin) and tigecycline (Tygacil)
- 9. Macrolides
 - a. Prototype: erythromycin lactobionate (Erythrocin IV)
 - b. Indications: staphylococcal, pneumococcal, streptococcal infections; infections due to atypical organisms such as chlamydia, mycoplasma, and mycobacteria
 - c. Usual dosage: 15 to 20 mg/kg over 24 hours or 4 mg/kg every 6 hours
 - d. Mode of administration: intermittent, continuous
 - e. Major side effects: abdominal pain, nausea, diarrhea, urticaria, and pain along the vein
 - f. Nursing considerations: monitor the infusion site for signs of phlebitis; reduce rate of infusion for pain at the infusion site
 - g. Patient/caregiver education: instruct patient to report pain or induration at infusion site
 - h. Related drug: azithromycin (Zithromax)
- 10. Quinolones
 - a. Prototype: ciprofloxacin lactate (Cipro)
 - b. Indications: genitourinary, sinus, prostate, skin, bone, and joint infections
 - c. Usual dosage: 200 to 400 mg every 12 hours
 - d. Mode of administration: intermittent
 - e. Major side effects: nausea, diarrhea, phlebitis, photosensitivity
 - f. Nursing considerations: infuse slowly over at least 60 minutes
 - g. Patient/caregiver education: instruct patient to avoid prolonged exposure to sunlight
 - h. Related drugs: levofloxacin (Levaquin) and moxifloxacin hydrochloride (Avelox)
- 11. Miscellaneous antibiotics
 - a. Aztreonam (Azactam)
 - 1) Indications: serious infections due to gram-negative organisms
 - 2) Usual dosage: 500 to 2,000 mg every 8 to 12 hours
 - 3) Mode of administration: push, intermittent
 - 4) Major side effects: diarrhea, rash, and phlebitis
 - 5) Nursing considerations: monitor for infusion site reactions
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
 - b. Chloramphenicol sodium succinate
 - 1) Indications: treatment of uncommon infections, such as Rocky Mountain Spotted Fever, typhoid fever, and anthrax
 - 2) Usual dosage: 12.5 mg/kg every 6 hours
 - 3) Mode of administration: intermittent
 - 4) Major side effects: aplastic anemia, optic neuritis, granulocytopenia, bone marrow depression, and gray syndrome
 - 5) Nursing considerations: monitor CBC at baseline and every 2 to 3 days, monitor serum concentrations with a goal of 5 to 20 mcg/mL
 - 6) Patient/caregiver education: instruct patient to report abnormal bruising or bleeding
 - c. Clindamycin phosphate (Cleocin)
 - 1) Indications: treatment of gram-positive and anaerobic infections
 - 2) Usual dosage: 600 to 900 mg every 8 hours
 - 3) Mode of administration: intermittent

- 4) Major side effects: colitis, nausea, diarrhea, and phlebitis
 - 5) Nursing considerations: monitor for infusion site reactions
 - 6) Patient/caregiver education: instruct patient to report any changes in bowel habits
- d. Colistimethate sodium (Coly-Mycin M)
- 1) Indications: treatment of multidrug-resistant gram-negative infections
 - 2) Usual dosage: 1.25 mg/kg every 6 hours
 - 3) Mode of administration: push, intermittent
 - 4) Major side effects: nephrotoxicity, paresthesias, and neuromuscular blockade
 - 5) Nursing considerations: monitor urine output, BUN, and serum creatinine
 - 6) Patient/caregiver education: instruct patient to report decreased urine output or paresthesias
- e. Daptomycin (Cubicin)
- 1) Indications: treatment of gram-positive infections such as endocarditis or bone and joint infections
 - 2) Usual dosage: 4 to 6 mg/kg every 24 hours
 - 3) Mode of administration: push, intermittent
 - 4) Major side effects: rhabdomyolysis and eosinophilic pneumonia
 - 5) Nursing considerations: monitor creatine kinase levels weekly
 - 6) Patient/caregiver education: instruct patient to report muscle pain
- f. Linezolid (Zyvox)
- 1) Indications: treatment of infections due to methicillin-resistant *Staphylococcus aureus* or vancomycin-resistant *Enterococcus*
 - 2) Usual dosage: 600 mg every 12 hours
 - 3) Major side effects: myelosuppression, neuropathy, lactic acidosis, and serotonin syndrome
 - 4) Nursing considerations: monitor CBC weekly
 - 5) Patient/caregiver education: instruct patient to report any new fevers
- g. Quinupristin/dalfopristin (Synercid)
- 1) Indications: infections due to methicillin-resistant *Staphylococcus aureus* or vancomycin-resistant *Enterococcus faecium*
 - 2) Usual dosage: 7.5 mg/kg every 8 hours
 - 3) Mode of administration: intermittent
 - 4) Major side effects: phlebitis, arthralgias, and QT prolongation
 - 5) Nursing considerations: not compatible with 0.9% sodium chloride, must be admixed in 5% dextrose in water
 - 6) Patient/caregiver education: instruct patient to report muscle pain
- h. Vancomycin hydrochloride (Vancocin)
- 1) Indications: treatment of gram-positive infections
 - 2) Usual dosage: 500 to 2,000 mg every 6 to 12 hours
 - 3) Mode of administration: intermittent
 - 4) Major side effects: nephrotoxicity, ototoxicity, injection site pain, thrombophlebitis, and “red-man syndrome” infusion reaction
 - 5) Nursing considerations: monitor BUN and serum creatinine, infuse slowly over 1 to 2 hours to minimize infusion-related reactions
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site or decreased urine output, changes in hearing, tinnitus, and dizziness

- i. Rifampin (Rifadin)
 - 1) Indications: treatment of tuberculosis and *Staphylococcus aureus* infection (in combination with other antibiotics)
 - 2) Usual dosage: 600 mg once daily
 - 3) Mode of administration: intermittent
 - 4) Major side effects: hepatotoxicity, flu-like syndrome, flushing, pruritis, red-orange colored body fluids
 - 5) Nursing considerations: monitor hepatic function tests, administer within 4 hours of preparation
 - 6) Patient/caregiver education: educate patient on the potential for red-orange-colored body fluids (tears, urine, sweat, feces, sputum), and instruct the patient to report pain at infusion site
- 12. Antifungals
 - a. Polyenes
 - 1) Prototype: amphotericin B (Fungizone)
 - 2) Indications: systemic fungal infections such as cryptococcosis, blastomycosis, coccidioidomycosis, histoplasmosis, and others
 - 3) Usual dosage: 1 to 1.5 mg/kg every 24 hours
 - 4) Mode of administration: slow infusion over 2 to 6 hours
 - 5) Major side effects: headache, rigors, fever, chills, nephrotoxicity, anorexia, thrombophlebitis, cardiac disturbances, anemia, and coagulation defects
 - 6) Nursing considerations: premedication with acetaminophen, diphenhydramine, and/or hydrocortisone may decrease the severity of infusion-related reactions; monitor urine output, BUN, and serum creatinine
 - 7) Patient/caregiver education: instruct patient to report fever, chills, rigors, or decreased urine output
 - 8) Related drugs: amphotericin B lipid complex (Abelcet), amphotericin B liposomal (AmBisome), amphotericin B cholesteryl sulfate (Amphotec)
 - b. Azoles
 - 1) Prototype: fluconazole (Diflucan)
 - 2) Indications: candidiasis, cryptococcal meningitis, and systemic fungal infections
 - 3) Usual dosage: 400 mg to 800 mg every 24 hours
 - 4) Mode of administration: intermittent; single daily dose not to exceed 200 mg/hour
 - 5) Major side effects: hepatotoxicity, abdominal pain, diarrhea, dry mouth, taste perversion, rash, and dizziness
 - 6) Nursing considerations: impaired renal function, monitor creatinine clearance, and monitor liver function
 - 7) Patient/caregiver education: instruct the patient regarding oral care
 - 8) Related drug: voriconazole (VFEND)
 - c. Echinocandins
 - 1) Prototype: caspofungin acetate (Cancidas)
 - 2) Indications: invasive candidiasis and aspergillosis
 - 3) Usual dosage: 70 mg IV loading dose, and then 50 mg every 12 hours
 - 4) Mode of administration: intermittent
 - 5) Major side effects: rash, pruritis, and liver enzyme elevation
 - 6) Nursing considerations: infuse over 60 minutes, should not be administered with other drugs due to incompatibilities

- 7) Patient/caregiver education: instruct patient to report new rash
 - 8) Related drugs: anidulafungin (Eraxis) and micafungin sodium (Mycamine)
13. Antivirals
- a. Prototype: acyclovir sodium (Zovirax)
 - 1) Indications: treatment of herpes simplex and varicella-zoster infections
 - 2) Usual dosage: 5 to 10 mg/kg every 8 hours
 - 3) Mode of administration: intermittent
 - 4) Major side effects: agitation, confusion, headache, hypotension, acute renal failure, phlebitis, and nausea
 - 5) Nursing considerations: use with caution in patients with impaired renal function; maintain adequate hydration before and during administration; assess renal function and output before and during therapy; infuse over at least 1 hour
 - 6) Patient/caregiver education: instruct patient to report any change in sensorium
 - b. Prototype: ganciclovir sodium (Cytovene-IV)
 - 1) Indications: cytomegalovirus retinitis, herpes virus
 - 2) Usual dosage: 5 mg/kg every 12 hours
 - 3) Mode of administration: intermittent
 - 4) Major side effects: neutropenia, thrombocytopenia, confusion, seizures, hepatotoxicity, nephrotoxicity, and phlebitis
 - 5) Nursing considerations: assess renal function and output before and during therapy; monitor liver function; monitor CBC for hematologic toxicity; infuse over at least 1 hour; maintain hydration level
 - 6) Patient/caregiver education: instruct patient to have effective birth control throughout the treatment to avoid birth defects
 - 7) Related drug: cidofovir (Vistide) and foscarnet (Foscavir)
 - c. Prototype: zidovudine (AZT, Retrovir)
 - 1) Indications: prevention of perinatal human immunodeficiency virus (HIV) transmission
 - 2) Usual dosage: 2 mg/kg loading dose over 1 hour, and then 1 mg/kg/hour continuous infusion
 - 3) Mode of administration: continuous, intermittent
 - 4) Major side effects: anorexia, neutropenia, gastrointestinal pain, headache, and fatigue
 - 5) Nursing considerations: assess central nervous system (CNS), monitor liver and renal studies, and monitor CBC
 - 6) Patient/caregiver education: teach patient to recognize and report signs of neutropenia
14. Antiprotozoals
- a. Metronidazole hydrochloride (Flagyl I.V.)
 - 1) Indications: infections due to anaerobic organisms such as intra-abdominal, gynecologic, bone, and joint infections
 - 2) Usual dosage: 500 mg every 6 to 8 hours
 - 3) Mode of administration: intermittent
 - 4) Major side effects: diarrhea, vomiting, nausea, metallic taste, neutropenia, pruritus, and thrombophlebitis
 - 5) Nursing considerations: monitor infusion site
 - 6) Patient/caregiver education: instruct the patient to report pain at infusion site

- b. Pentamidine isethionate (Pentam 300)
 - 1) Indications: treatment and prevention of *Pneumocystis jiroveci* pneumonia; treatment of trypanosomiasis, visceral leishmaniasis, and babesiosis
 - 2) Usual dosage: 4 mg/kg every 24 hours
 - 3) Mode of administration: single daily dose given in a 60- to 120-minute infusion
 - 4) Major side effects: nephrotoxicity, hypotension, anemia, leukopenia, thrombocytopenia, nausea, bad taste in mouth, hypocalcemia, and hypoglycemia
 - 5) Nursing considerations: side effects may be life-threatening; monitor blood pressure (BP) before, during, and after infusion; keep patient in supine position; monitor chemistry panel
 - 6) Patient/caregiver education: instruct patient to report changes in sensorium
- 15. Sulfonamide combinations
 - a. Co-trimoxazole (trimethoprim/sulfamethoxazole; Bactrim, Septra)
 - 1) Indications: severe urinary tract infections, treatment of nocardiosis, toxoplasmosis, and *Pneumocystis jiroveci* pneumonia
 - 2) Usual dosage: 5 mg of trimethoprim/kg every 6 to 8 hours
 - 3) Mode of administration: intermittent
 - 4) Major side effects: nausea, vomiting, anorexia, rash, urticaria, and nephrotoxicity
 - 5) Nursing considerations: maintain adequate hydration to prevent crystalluria and stone formation
 - 6) Patient/caregiver education: instruct patient concerning hydration

B. Central Nervous System Agents

- 1. Opiate—analgesics
 - a. Prototype: morphine sulfate (Astramorph, Duramorph)
 - b. Indications: severe, acute pain or moderate-to-severe chronic pain
 - c. Usual dosage: varies with use and clinical response
 - d. Mode of administration: push, continuous
 - e. Major side effects: constipation, respiratory depression, circulatory depression, and hypersensitivity
 - f. Nursing considerations: use with caution in head injury or increased intracranial pressure; monitor respiratory rate and level of consciousness; naloxone hydrochloride (Narcan) should be readily available; implement bowel management regimen
 - g. Patient/caregiver education: instruct caregiver to report excessive sedation/sleepiness; patient to report breathing difficulties
 - h. Related drugs: hydromorphone hydrochloride (Dilaudid), fentanyl citrate (Sublimaze), meperidine hydrochloride (Demerol), remifentanyl hydrochloride (Ultiva), sufentanil hydrochloride (Sufenta), buprenorphine hydrochloride (Buprenex), butorphanol tartrate (Stadol), and nalbuphine hydrochloride (Nubain)
- 2. Opiate—antagonists
 - a. Prototype: naloxone hydrochloride (Narcan)
 - b. Indications: narcotic-induced depression
 - c. Usual dose: 0.4 to 2 mg
 - d. Mode of administration: push, continuous
 - e. Major side effects: nausea, vomiting, hypotension or hypertension, and reversal of analgesia

- f. Nursing considerations: monitor respiratory rate; duration of narcotic action may exceed that of naloxone hydrochloride
- g. Patient/caregiver education: instruct patient to report nausea
- 3. Sedatives, hypnotics, and anxiolytics
 - a. Benzodiazepine
 - 1) Prototype: diazepam (Valium)
 - 2) Indications: treatment of anxiety, seizures, and muscle spasms; sedation
 - 3) Usual dosage: 2 to 10 mg every 3 to 4 hours; may repeat in 1 hour to a maximum of 30 mg in 8 hours
 - 4) Mode of administration: push
 - 5) Major side effects: apnea, hypotension, ataxia, blurred vision, confusion, depression, amnesia, phlebitis, respiratory depression, and drowsiness
 - 6) Nursing considerations: administer directly into the vein; avoid smaller veins; inject into administration set closest to infusion site only when direct intravenous injection is not feasible; flush before and immediately after injection with 0.9% sodium chloride
 - 7) Patient/caregiver education: instruct patient to report pain at infusion site
 - 8) Related drugs: lorazepam (Ativan) and midazolam (Versed)
 - b. Benzodiazepine antagonist
 - 1) Prototype: flumazenil (Romazicon)
 - 2) Indications: reversal of benzodiazepine effects
 - 3) Usual dosage: 0.2 mg every minute until effects are reversed, maximum dosage 1 mg in 20 minutes
 - 4) Mode of administration: push
 - 5) Major side effects: seizures, hypoventilation, and withdrawal reactions
 - 6) Nursing considerations: resedation may occur, monitor patient for 1 to 2 hours after dosage
 - 7) Patient/caregiver education: instruct patient to report respiratory difficulties
 - c. Barbiturate
 - 1) Prototype: phenobarbital sodium (Luminal)
 - 2) Indication: provide prolonged sedation; treatment of seizures
 - 3) Usual dose: varies with clinical indication; 100 to 320 mg
 - 4) Mode of administration: push
 - 5) Major side effects: respiratory depression, dermatitis, apnea, and hypotension
 - 6) Nursing considerations: observe patient continuously; maintain patent airway
 - 7) Patient/caregiver education: instruct patient to avoid alcohol or other CNS depressants
 - 8) Related drug: pentobarbital sodium (Nembutal)
- 4. Anticonvulsants
 - a. Prototype: phenytoin sodium (Dilantin)
 - b. Indications: seizure disorders
 - c. Usual dosage: 6 to 7 mg/kg/day in 3 to 4 divided doses
 - d. Mode of administration: push; intermittent
 - e. Major side effects: nystagmus, ataxia, lethargy, hypotension
 - f. Nursing considerations: monitor phenytoin levels; toxicity occurs at levels >20 mcg/mL; infuse no faster than 50 mg/minute; alkaline solution that is highly irritating to veins, use CVAD whenever possible for administration, flush with 0.9% sodium chloride after administration; tissue necrosis may occur with extravasation

- g. Patient/caregiver education: instruct patient to report abnormal movements
- h. Related drugs: fosphenytoin sodium (Cerebyx); valproate sodium (Depacon); levetiracetam (Keppra); phenobarbital sodium (Luminal); magnesium sulfate
- 5. Miscellaneous CNS agents
 - a. Droperidol (Inapsine)
 - 1) Indications: induction of anesthesia; prevention of postoperative nausea and vomiting
 - 2) Usual dosage: 2.5 mg
 - 3) Mode of administration: push
 - 4) Major side effects: QT prolongation, drowsiness, extrapyramidal reactions, and neuroleptic malignant syndrome
 - 5) Nursing considerations: ECG monitoring must be performed before giving droperidol
 - 6) Patient/caregiver education: instruct patient to report abnormal movements
 - b. Dexmedetomidine hydrochloride (Precedex)
 - 1) Indications: sedation; adjunct to anesthesia
 - 2) Usual dosage: 1 mcg/kg loading dose over 10 minutes; continuous infusion 0.2 to 0.7 mcg/kg/hour
 - 3) Mode of administration: continuous
 - 4) Major side effects: hypotension and bradycardia
 - 5) Nursing considerations: patients may respond to stimulation
 - 6) Patient/caregiver education: instruct caregiver that patient may respond if stimulated
 - c. Bupivacaine
 - 1) Indications: local anesthesia, spinal anesthesia, and nerve block
 - 2) Usual dosage: varies depending on indication
 - 3) Mode of administration: epidural or peripheral nerve block and subarachnoid injection
 - 4) Major side effects: transient burning at injection site; inadvertent intravascular injection may result in seizures, cardiorespiratory depression, or coma
 - 5) Nursing considerations: use proper injection technique to avoid intravascular injection
 - 6) Patient/caregiver education: instruct patient to report palpitations or difficulty breathing
 - d. Dantrolene sodium (Dantrium)
 - 1) Indications: malignant hyperthermia and neuroleptic malignant syndrome
 - 2) Usual dosage: 2.5 mg/kg/dose, may repeat up to a total of 10 mg/kg
 - 3) Mode of administration: rapid IV push
 - 4) Major side effects: muscle weakness, drowsiness, dizziness, malaise, fatigue, and lightheadedness
 - 5) Nursing considerations: reconstitute only with sterile water for injection; solution should be clear; may transfer to empty plastic bag for administration; glass containers should not be used due to precipitation risk
 - 6) Patient/caregiver education: instruct patient to report lightheadedness or dizziness

- e. Propofol (Diprivan)
 - 1) Indications: induction or maintenance of anesthesia
 - 2) Usual dosage: 20 mg to 50 mg bolus; 50 to 200 mcg/kg/minute infusion
 - 3) Mode of administration: push; continuous
 - 4) Major side effects: hypotension, bradycardia, apnea, involuntary movements, pain at injection site, propofol infusion syndrome
 - 5) Nursing considerations: monitor vital signs frequently, strict aseptic technique must be used to prevent contamination with microorganisms, and change administration set every 12 hours
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
- f. Atropine sulfate
 - 1) Indications: reverse poisonous effects of pesticides or chemical warfare agents; GI or biliary tract spasms; reduce respiratory tract secretions
 - 2) Usual dosage: 0.5 to 2 mg IV every 5 to 10 minutes as needed
 - 3) Mode of administration: push
 - 4) Major side effects: blurred vision, dilation of pupils, postural hypotension, and urinary retention
 - 5) Nursing considerations: administer rapidly as slow injection may cause heart rate slowing
 - 6) Patient/caregiver education: instruct patient concerning visual change
- g. Promethazine hydrochloride (Phenergan)
 - 1) Indications: antiemetic; sedation; may be used as a preoperative adjunct to anesthesia
 - 2) Usual dosage: 12.5 to 25 mg
 - 3) Mode of administration: push, intermittent
 - 4) Major side effects: sedation, blurred vision, extrapyramidal reactions, injection site reactions including thrombophlebitis and tissue necrosis if extravasation occurs
 - 5) Nursing considerations: dilute before administration; preferable to give as IVPB or slow IV push into a free-flowing line; monitor for extravasation as significant tissue necrosis can occur
 - 6) Patient/caregiver education: instruct patient concerning visual change and sedation; instruct patient to report any pain at infusion site

C. Cardiovascular Agents

- 1. Sympathomimetic (adrenergic) agents
 - a. Dopamine hydrochloride
 - 1) Indications: hypotension and shock
 - 2) Usual dosage: initially 2 to 5 mcg/kg/minute; 5 to 10 mcg/kg/minute may be required in the critically ill patient; gradually increase by 5 to 10 mcg/kg/minute at 10- to 30-minute intervals until optimum response is attained; average dose is 20 mcg/kg/minute
 - 3) Mode of administration: continuous
 - 4) Major side effects: ectopic beats, hypertension, hypotension, vasoconstriction, widened QRS complex, aberrant conduction, and tissue necrosis after extravasation
 - 5) Nursing considerations: monitor urine output continuously; monitor BP and central venous pressure; ensure patency of venous access device; use CVAD whenever possible to provide adequate hemodilution of drug; avoid extravasation; antidote is injection of 5 to 10 mg of

- phentolamine mesylate (Regitine) diluted in 10 to 15 mL 0.9% sodium chloride; continue to monitor for hypotension after phentolamine administration; use electronic infusion device
- 6) Patient/caregiver education: instruct patient to notify nurse of pain at infusion site
- b. Norepinephrine bitartrate (Levophed)
- 1) Indications: hypotension; shock
 - 2) Usual dose: 8 to 12 mcg/minute initial dose, and then titrate to maintain goal BP
 - 3) Mode of administration: continuous
 - 4) Major side effects: bradycardia, chest pain, vomiting, photophobia, pallor, and tissue necrosis after extravasation
 - 5) Nursing considerations: monitor BP every 2 minutes until stable, and every 5 minutes thereafter; ensure patency of venous access device; use CVAD whenever possible to provide adequate hemodilution of drug; avoid extravasation; antidote is injection of 5 to 10 mg of phentolamine mesylate (Regitine) diluted in 10 to 15 mL of 0.9% sodium chloride; continue to monitor for hypotension after phentolamine administration; use electronic infusion device
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
- c. Dobutamine hydrochloride (Dobutrex)
- 1) Indications: short-term inotropic support; long-term support while awaiting heart transplant; palliative care of end-stage heart failure
 - 2) Usual dosage: 2 to 20 mcg/kg/minute to a maximum of 40 mcg/kg/minute
 - 3) Mode of administration: continuous
 - 4) Major side effects: anginal pain, chest pain, palpitations, headache, and nausea
 - 5) Nursing considerations: monitor patient's heart rate, BP, urine output; use electronic infusion device
 - 6) Patient/caregiver education: instruct patient to report changes in urine output, headache, or nausea
- d. Epinephrine hydrochloride (adrenalin)
- 1) Indications: drug of choice for anaphylactic shock and antidote of choice for histamine overdose and allergic reactions
 - 2) Usual dose: 0.1 to 0.25 mg of 1:10,000 solution
 - 3) Mode of administration: push
 - 4) Major side effects: anxiety, vertigo, and palpitations
 - 5) Nursing considerations: administer with extreme caution; check BP every 5 minutes for 1 hour
 - 6) Patient/caregiver education: instruct patient to report change in sensorium or anxiety level
- e. Isoproterenol hydrochloride (Isuprel)
- 1) Indications: atrioventricular heart block
 - 2) Usual dosage: bolus dose 0.02 to 0.06 mg; infusion dose 2 to 20 mcg/minute
 - 3) Mode of administration: push, continuous
 - 4) Major side effects: angina, flushing, palpitations, sweating, nausea, and vomiting
 - 5) Nursing considerations: monitor the rate of infusion and titrate to heart rate and rhythm; do not use if the solution is pink; use electronic infusion control device
 - 6) Patient/caregiver education: instruct patient to report episodes of chest pain or flushing

2. Cardiotonic agents

a. Digoxin (Lanoxin)

- 1) Indications: congestive heart failure, atrial fibrillation, and atrial flutter
- 2) Usual dosage: 0.25 to 0.5 mg as initial dose, followed by 0.25 to 0.5 mg at 4- to 6-hour intervals; maintenance dose of 0.0625 to 0.5 mg daily
- 3) Mode of administration: push
- 4) Major side effects: partial atrioventricular block, anorexia, color vision changes, confusion, diarrhea, nausea, and vomiting
- 5) Nursing considerations: monitor electrolyte and digoxin levels: calcium gluconate is contraindicated in digitalis toxicity; in severe intoxication, hyperkalemia may be present; may be administered undiluted
- 6) Patient/caregiver education: instruct patient to report anorexia or nausea

b. Milrinone lactate (Primacor)

- 1) Indications: congestive heart failure (short-term management), long-term support while awaiting heart transplant; palliative care of end-stage heart failure
- 2) Usual dosage: loading dose 50 mcg/kg; maintenance dose of 0.25 to 0.75 mcg/kg/minute
- 3) Mode of administration: push, continuous
- 4) Major side effects: ventricular arrhythmias, hypotension, chest pain, headache, and pain at infusion site
- 5) Nursing considerations: use with caution in renal or hepatic dysfunction; monitor BP and urinary output
- 6) Patient/caregiver education: instruct patient to report pain at infusion site
- 7) Related drug: inamrinone lactate (Inocor)

3. Antiarrhythmic agents

a. Class Ia: quinidine gluconate

- 1) Indications: treatment of cardiac arrhythmias and malaria
- 2) Usual dosage: 0.25 mg/kg/minute
- 3) Mode of administration: continuous
- 4) Major side effects: cramps, nausea, hypotension, QT prolongation, apprehension, rash, and tinnitus
- 5) Nursing considerations: use with caution in the presence of heart block or hepatic dysfunction; monitor BP and heart rhythm continuously during infusion; use electronic infusion device
- 6) Patient/caregiver education: instruct patient to report abdominal cramping, rash, and tinnitus

b. Class Ia: procainamide hydrochloride (Pronestyl)

- 1) Indications: ventricular arrhythmias and wide-complex tachycardias; when the use of lidocaine is contraindicated
- 2) Usual dosage: 500 to 600 mg loading dose; infusion of 2 to 6 mg/minute
- 3) Mode of administration: push, intermittent, continuous
- 4) Major side effects: drug-induced systemic lupus syndrome, hypotension, ventricular arrhythmias, and asystole
- 5) Nursing considerations: monitor ECG continuously and vital signs frequently; monitor renal function; use electronic infusion device
- 6) Patient/caregiver education: instruct patient to report dizziness

c. Class Ib: lidocaine hydrochloride (Xylocaine)

- 1) Indications: ventricular arrhythmias
- 2) Usual dosage: 50 to 100 mg bolus, followed by infusion of 1 to 4 mg/minute
- 3) Mode of administration: push, continuous

- 4) Major side effects: blurred vision, vertigo, twitching, vomiting, hypotension, bradycardia, and seizures
- 5) Nursing considerations: use with caution in severe renal or hepatic disease, hypovolemia, shock, heart block; use electronic infusion device
- 6) Patient/caregiver education: instruct patient to report visual changes
- d. Class III: ibutilide fumarate (Corvert)
 - 1) Indications: atrial fibrillation or flutter
 - 2) Usual dosage: 1 mg
 - 3) Mode of administration: push or intermittent, in 10-minute injection
 - 4) Major side effects: prolonged QT interval, hypertension, nausea, vomiting, and palpitations
 - 5) Nursing considerations: assess baseline ECG and QT interval
 - 6) Patient/caregiver education: instruct patient to report faintness, difficulty breathing, and chest discomfort
- e. Class III: amiodarone hydrochloride (Cordarone)
 - 1) Indications: ventricular and supraventricular arrhythmias
 - 2) Usual dosage: 150 to 300 mg bolus over 10 minutes; 0.5 to 1 mg/minute infusion
 - 3) Mode of administration: intermittent, continuous
 - 4) Major side effects: pulmonary toxicity, hepatotoxicity, worsening arrhythmia (especially with abnormal electrolytes), hyper- or hypothyroidism, injection site reactions including pain, phlebitis, and necrosis
 - 5) Nursing considerations: assess baseline ECG and QT interval, monitor liver function and thyroid tests, monitor electrolytes, evaluate infusion site for the signs of extravasation
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site or difficulty breathing
- f. Class IV: adenosine (Adenocard, Adenoscan)
 - 1) Indication: supraventricular arrhythmias; adjunctive agent in cardiac stress tests
 - 2) Usual dosage: 6 mg initially, 12 mg if no response for arrhythmias; 140 mcg/kg/minute infusion for 6 minutes during cardiac stress test
 - 3) Mode of administration: push, in 1- to 2-second injection; continuous
 - 4) Major side effects: shortness of breath, transient facial flushing, chest pain, hypotension, and asystole
 - 5) Nursing considerations: monitor heart rate every 15 to 30 seconds; monitor ECG continuously; monitor BP throughout treatment; must push rapidly for desired therapeutic effect due to short half-life
 - 6) Patient/caregiver education: instruct patient to report facial flushing, shortness of breath, and dizziness
4. Calcium channel blocking agents
 - a. Verapamil hydrochloride (Apo-Verap, Isoptin)
 - 1) Indications: supraventricular tachyarrhythmias
 - 2) Usual dosage: 5 to 10 mg; may repeat in 30 minutes if needed
 - 3) Mode of administration: push over 2 minutes
 - 4) Major side effects: abdominal discomfort, nausea, bradycardia, AV block, hypotension, vertigo, and headache
 - 5) Nursing considerations: monitor BP and ECG during administration; protect vial from light; do not use if the solution is discolored
 - 6) Patient/caregiver education: instruct patient to report headache

- b. Diltiazem (Cardizem)
 - 1) Indications: supraventricular tachyarrhythmias
 - 2) Usual dosage: 10 to 20 mg bolus; 5 to 15 mg/hour infusion
 - 3) Mode of administration: push, continuous
 - 4) Major side effects: hypotension, bradycardia, nausea, headache, infusion site pain
 - 5) Nursing considerations: monitor BP and ECG during administration
 - 6) Patient/caregiver education: instruct patient to report headache or pain at infusion site
 - c. Nicardipine (Cardene)
 - 1) Indications: hypertension
 - 2) Usual dosage: 5 to 15 mg/hour infusion
 - 3) Mode of administration: continuous
 - 4) Major side effects: tachycardia, hypotension, headache, and dizziness
 - 5) Nursing considerations: monitor BP and ECG during administration
 - 6) Patient/caregiver education: instruct patient to report headache or dizziness
5. Beta-blocking agents
- a. Esmolol hydrochloride (Brevibloc)
 - 1) Indications: supraventricular tachycardia
 - 2) Usual dosage: loading dose 500 mcg/kg; maintenance dose 50 to 200 mcg/kg/minute
 - 3) Mode of administration: continuous
 - 4) Major side effects: induration at site, confusion, dizziness, nausea, speech disorders, taste disorders, and tissue necrosis after extravasation
 - 5) Nursing considerations: monitor BP and cardiovascular status; monitor infusion site; use electronic infusion device
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
 - b. Labetalol hydrochloride (Normodyne)
 - 1) Indications: severe hypertension
 - 2) Usual dose: 20 to 80 mg as initial dose; continuous: 0.5 to 2 mg/minute, not to exceed a 300-mg total
 - 3) Mode of administration: push, continuous
 - 4) Major side effects: diaphoresis, vertigo, moderate hypotension, numbness, and severe postural hypotension
 - 5) Nursing considerations: keep patient supine; monitor BP before and 5 and 10 minutes after direct injection
 - 6) Patient/caregiver education: instruct patient to report dizziness or shortness of breath
 - 7) Related drugs: propranolol hydrochloride (Inderal) and metoprolol tartrate (Lopressor)
6. Central alpha agonist
- a. Methyldopate hydrochloride (Aldomet)
 - 1) Indications: acute hypertensive crisis
 - 2) Usual dosage: 250 to 500 mg every 6 hours
 - 3) Mode of administration: intermittent
 - 4) Major side effects: vertigo, drowsiness, and mild postural hypotension
 - 5) Nursing considerations: use with caution in hepatic disease; monitor BP and urinary output
 - 6) Patient/caregiver education: instruct patient to report dizziness

7. Vasodilator agents
 - a. Sodium nitroprusside (Nipride)
 - 1) Indications: hypertensive emergencies and cardiogenic shock (reduce preload and afterload)
 - 2) Usual dosage: 3 to 10 mcg/kg/minute; dose varies depending on the response
 - 3) Mode of administration: continuous
 - 4) Major side effects: hypotension, tissue sloughing with extravasation, and cyanide toxicity
 - 5) Nursing considerations: 5% dextrose in water is the only compatible infusate; monitor infusion site; monitor for signs and symptoms of cyanide toxicity; use electronic infusion device
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site or shortness of breath
 - b. Nitroglycerin (Nitro-bid IV, Tridil)
 - 1) Indications: hypertension (perioperative); acute myocardial infarction; angina pectoris
 - 2) Usual dosage: 5 mcg/minute initially; titrate to obtain response
 - 3) Mode of administration: continuous
 - 4) Major side effects: headache, hypotension, abdominal pain, nausea, and vertigo
 - 5) Nursing considerations: use glass containers and administration sets not made of polyvinyl chloride; monitor BP and heart rhythm; use electronic infusion device
 - 6) Patient/caregiver education: instruct patient to report headache, dizziness, and abdominal pain
 - c. Hydralazine hydrochloride (Apresoline)
 - 1) Indications: hypertension; cardiogenic shock; and congestive heart failure
 - 2) Usual dose: 5 to 20 mg
 - 3) Mode of administration: push
 - 4) Major side effects: headache, tachycardia, sodium retention, and drug-induced lupus syndrome
 - 5) Nursing considerations: monitor BP; monitor CBC and chemistry panel
 - 6) Patient/caregiver education: instruct patient to report drowsiness, muscle or joint pain, chest pain, and tingling
 - 7) Related drug: enalaprilat (Vasotec)
8. Anticholinergic agent
 - a. Atropine sulfate
 - 1) Indications: sinus bradycardia and atrioventricular block
 - 2) Usual dosage: 0.5 mg IV every 3 to 5 minutes; maximum cumulative dose 3 mg
 - 3) Mode of administration: push
 - 4) Major side effects: blurred vision, dilation of pupils, postural hypotension, and urinary retention
 - 5) Nursing considerations: administer rapidly as slow injection may cause heart rate slowing
 - 6) Patient/caregiver education: instruct patient concerning visual changes

D. Hematologic Agents

1. Hemostatic
 - a. Prototype: aminocaproic acid (Amicar)
 - b. Indications: treatment of hemorrhage caused by the overactivity of fibrinolytic system
 - c. Usual dosage: initial dose 4 to 5 g; follow with 1 to 1.25 g/hour or at hourly intervals for 6 to 8 hours
 - d. Mode of administration: intermittent, continuous
 - e. Major side effects: diarrhea, nausea, hypotension, vertigo, bradycardia, rash, and skeletal muscle weakness
 - f. Nursing considerations: rapid administration may cause hypotension, bradycardia, or dysrhythmia; monitor carefully
 - g. Patient/caregiver education: instruct patient to report episodes of dizziness
2. Anticoagulants
 - a. Prototype: antithrombin III (AT-III, Thrombate III)
 - 1) Indications: prevention of thromboembolism due to antithrombin III deficiency; heparin resistance
 - 2) Usual dosage: individualized based on weight, baseline antithrombin III activity, and desired antithrombin III activity
 - 3) Mode of administration: push, intermittent
 - 4) Major side effects: hemorrhage, hematoma formation, and sensitivity
 - 5) Nursing considerations: monitor for bleeding episodes (bruising, nosebleeds, bleeding gums) and avoid unnecessary venipunctures
 - 6) Patient/caregiver education: instruct patient to watch for bruises, bleeding gums, hematuria, and to use an electric razor when shaving
 - b. Prototype: heparin sodium
 - 1) Indications: thrombosis and emboli (prevention and treatment); maintains patency of vascular catheters
 - 2) Usual dosage: loading dose 50 to 80 units/kg followed by continuous infusion 12 to 18 units/kg/hour
 - 3) Mode of administration: push, continuous
 - 4) Major side effects: bleeding, prolonged coagulation time, bruising, epistaxis, hematuria, pain, and headache
 - 5) Nursing considerations: use electronic infusion device; most important laboratory value for dose regulating is the PTT or anti-factor Xa; when administered for venous thrombosis, PTT should be maintained at 1.5 to 2 times the control value or anti-factor Xa of 0.3 to 0.7 International units/mL; antidote for overdose is protamine sulfate
 - 6) Patient/caregiver education: instruct patient to watch for bruises, bleeding gums, hematuria, and to use an electric razor when shaving
 - 7) Related drugs: lepirudin (Refludan), argatroban (Argatroban), bivalirudin (Angiomax)
3. Antagonist (antiheparin)
 - a. Prototype: protamine sulfate
 - b. Indication: heparin reversal
 - c. Usual dosage: 1 mg for every 100 USP units of heparin sodium given; may repeat in 10 to 15 minutes; never exceed 50 mg in any 10-minute period; dose decreases rapidly with time elapsed after heparin sodium injection
 - d. Mode of administration: push over 10 minutes

- e. Major side effects: dyspnea, bradycardia, hypotension, and feeling of warmth
 - f. Nursing considerations: monitor PTT; potential for hypersensitivity in patients with fish allergies
 - g. Patient/caregiver education: instruct patient to report episodes of bleeding
4. Thrombolytics
- a. Prototype: alteplase (Activase)
 - b. Indications: acute massive pulmonary emboli; acute myocardial infarction; acute embolic stroke; restore function of VADs
 - c. Usual dosage: varies with use and clinical indications
 - d. Mode of administration: push, intermittent
 - e. Major side effects: bleeding, nausea, vomiting, and arrhythmias
 - f. Nursing considerations: obtain baseline ECG and monitor ECG continuously; monitor bleeding parameters and vital signs; avoid invasive procedures, including intravenous and intramuscular injections, rotating tourniquets; use electronic infusion device. For catheter clearance: instill adequate volume to fill catheter lumen; allow solution to dwell for 30 minutes to 2 hours
 - g. Patient/caregiver education: instruct patient to avoid injury and to report episodes of bleeding
 - h. Related drugs: tenecteplase (TNKase) and reteplase (Retavase)
5. Antianemic
- a. Prototype: epoetin alfa (Procrit, Epogen)
 - b. Indications: anemia
 - c. Usual dosage: titrated to desired hemoglobin
 - d. Mode of administration: push
 - e. Major side effects: hypertension and thromboembolism
 - f. Nursing considerations: monitor BP frequently, ensure patency of VAD due to increased blood viscosity and risk for occluded VAD
 - g. Patient/caregiver education: instruct patient to report any new swelling
 - h. Related drug: darbepoetin alfa (Aranesp)
6. Colony-stimulating factor
- a. Prototype: filgrastim (Neupogen)
 - b. Indications: decreased duration of neutropenia; reduced time to neutrophil recovery; decreased incidence of infection
 - c. Usual dosage: 5 mcg/kg/24 hour; may increase if desired response not attained
 - d. Mode of administration: intermittent; continuous
 - e. Major side effects: bone pain; itching, redness, and swelling at injection site
 - f. Nursing considerations: monitor CBC and platelet count before chemotherapy begins and twice weekly thereafter to avoid leukocytosis
 - g. Patient/caregiver education: instruct patient to report any signs of infection or allergic reaction
 - h. Related drug: pegfilgrastim (Neulasta)
7. Chelating agents
- a. Prototype: deferoxamine mesylate (Desferal)
 - b. Indications: acute iron intoxication or chronic iron overload
 - c. Usual dosage: initial dosage 1,000 mg followed by 500 mg every 4 hours for two additional doses; may repeat as needed until iron reaches desired level
 - d. Mode of administration: intramuscular administration is preferred; may be given as subcutaneous infusion; IV administration must be slow (no faster than 15 mg/kg/hour)

- e. Major side effects: pain at injection site, anaphylaxis, blurred vision, tachycardia, flushing, and hypotension
- f. Nursing considerations: monitor serum ferritin or iron concentration; monitor blood gases, central venous pressure, and renal function
- g. Patient/caregiver education: instruct patient to report hearing or vision changes
- h. Related drug: dexrazoxane (Zinecard)

E. Electrolyte and Water Balance Agents

- 1. Replacement solutions
 - a. Calcium chloride (Kalcinate)
 - 1) Indications: tetany associated with hypocalcemia
 - 2) Usual dosage: varies with clinical indication
 - 3) Mode of administration: push
 - 4) Major side effects: bradycardia, cardiac arrest, tingling sensation, and tissue necrosis after extravasation
 - 5) Nursing considerations: determine the patency of VAD before administration; monitor serum calcium, vital signs, and infusion site for pain and induration
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
 - b. Calcium gluconate
 - 1) Indications: calcium deficiency caused by vitamin D deficiency; magnesium sulfate toxicity; electrolyte imbalance
 - 2) Usual dosage: varies with clinical indication
 - 3) Mode of administration: push, continuous
 - 4) Major side effects: bradycardia, cardiac arrest, flushing, tingling sensation, and tissue necrosis after extravasation
 - 5) Nursing considerations: determine the patency of VAD before administration; monitor serum calcium, vital signs, and infusion site for pain and induration
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
 - c. Sodium chloride
 - 1) Indications: sodium and chloride ion imbalance
 - 2) Usual dosage: varies with clinical indication
 - 3) Mode of administration: continuous
 - 4) Major side effects: anorexia, dehydration, disorientation, distention, edema, and hypertension
 - 5) Nursing considerations: monitor intake and output, vital signs, and serum electrolyte levels
 - 6) Patient/caregiver education: instruct patient to report change in sensorium
 - d. Potassium chloride/acetate
 - 1) Indications: potassium deficiency (prevention or treatment)
 - 2) Usual dosage: varies with clinical condition
 - 3) Mode of administration: intermittent, continuous
 - 4) Major side effects: bradycardia, ECG changes, voluntary muscle paralysis, weakness, and pain at infusion site
 - 5) Nursing considerations: monitor cardiac status for dose in excess of 10 mEq/hour; monitor serum potassium; determine the patency of VAD before administration
 - 6) Patient/caregiver education: instruct the patient to report pain at infusion site

2. Agents for acid/base balance
 - a. Ammonium chloride
 - 1) Indications: metabolic alkalosis caused by chloride loss
 - 2) Usual dosage: varies with patient condition and tolerance
 - 3) Mode of administration: continuous
 - 4) Major side effects: hypokalemia, hyperglycemia, metabolic acidosis, pallor, and pain at infusion site
 - 5) Nursing considerations: monitor respirations and serum electrolyte levels
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
 - b. Sodium bicarbonate
 - 1) Indications: metabolic acidosis, hyperkalemia
 - 2) Usual dosage: adjusted consistent with pH, PaCO_2 , calculated base deficit, and fluid limitations
 - 3) Mode of administration: push, continuous
 - 4) Major side effects: hyperexcitability, tetany, headache, edema, nausea, alkalosis, tissue necrosis after extravasation, and hypokalemia
 - 5) Nursing considerations: monitor infusion site, serum electrolytes, and arterial blood gases
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
3. Diuretics
 - a. Chlorothiazide sodium (Diuril)
 - 1) Indications: edema and hypertension
 - 2) Usual dosage: 500 to 1,000 mg once or twice daily
 - 3) Mode of administration: push, intermittent
 - 4) Major side effects: hypokalemia, diarrhea, nausea, vertigo, photosensitivity, and tissue necrosis after extravasation
 - 5) Nursing considerations: determine the patency of VAD before administration; monitor BP, serum electrolytes levels, intake and output, and infusion site for pain and induration
 - 6) Patient/caregiver education: instruct patient to report pain at infusion site
 - b. Furosemide (Lasix)
 - 1) Indications: edema and hypertension
 - 2) Usual dose: 20 to 200 mg once to four times daily
 - 3) Mode of administration: push, intermittent, continuous
 - 4) Major side effects: hypokalemia, tinnitus, nausea, photosensitivity, orthostatic hypotension, and blood volume reduction
 - 5) Nursing considerations: monitor BP frequently, especially during initial therapy
 - 6) Patient/caregiver education: instruct patient that hypotension may cause dizziness, so patient should request assistance with ambulation; instruct patient to report cramps or dizziness
 - 7) Related drugs: bumetanide (Bumex), ethacrynate sodium (Edecrin), and torsemide (Demadex)
4. Volume expanders
 - a. Hetastarch (Hespan, Hextend)
 - 1) Indications: shock (adjunctive therapy)
 - 2) Usual dosage: depends on the degree of fluid loss
 - 3) Mode of administration: continuous
 - 4) Major side effects: vomiting and peripheral edema, may interfere with platelet function

- 5) Nursing considerations: maintain adequate patient hydration; monitor pulse, BP, intake and output, CBC, and serum electrolyte levels; observe patient for increased bleeding
- 6) Patient/caregiver education: instruct patient to report changes in skin
- b. Dextran 40 (LMD)
 - 1) Indications: shock (adjunctive therapy); agent also used as a volume expander
 - 2) Usual dosage: varies based on the degree of blood and fluid loss
 - 3) Mode of administration: continuous
 - 4) Major side effects: hypotension, anaphylaxis, and renal failure
 - 5) Nursing considerations: monitor BP, pulse, and urinary output every 5 to 15 minutes for the first hour and hourly thereafter
 - 6) Patient/caregiver education: instruct patient to report changes in sensorium or sensations
 - 7) Related drug: dextran 70
- c. Mannitol (Osmitol)
 - 1) Indications: cerebral edema, elevated intraocular pressure, and acute renal failure (oliguric phase)
 - 2) Usual dosage: varies with clinical indication
 - 3) Mode of administration: intermittent
 - 4) Major side effects: convulsions, blurred vision, vertigo, headache, urinary retention, polyuria followed by oliguria, chills, chest pain, edema, fluid and electrolyte imbalance, extravasation may cause tissue necrosis
 - 5) Nursing considerations: administer test dose in 3- to 5-minute period; monitor for increased urine output; monitor serum electrolyte levels and infusion site; maintain patient hydration; crystals must be dissolved before administration; use a 170-micron in-line filter
 - 6) Patient/caregiver education: instruct patient to report

F. Gastrointestinal Agents

1. Histamine (H_2) antagonist
 - a. Prototype: famotidine (Pepcid I.V.)
 - b. Indications: duodenal or gastric ulcers, pathologic hypersecretory conditions; a component of parenteral nutrition formula
 - c. Usual dosage: 20 mg every 12 hours
 - d. Mode of administration: push, intermittent
 - e. Major side effects: constipation, diarrhea, nausea, headache, and vertigo
 - f. Nursing considerations: if necessary for pain relief, increase the frequency of dose and not amount
 - g. Patient/caregiver education: instruct patient to report the change in sensorium
 - h. Related drugs: ranitidine (Zantac) and cimetidine hydrochloride (Tagamet)
2. Proton pump inhibitor
 - a. Prototype: pantoprazole sodium (Protonix I.V.)
 - b. Indications: gastroesophageal reflux, duodenal or gastric ulcers, pathologic hypersecretory conditions, management of gastrointestinal bleeding
 - c. Usual dosage: 40 mg every 12 to 24 hours; for GI bleeding 80 mg bolus and 8 mg/hour infusion
 - d. Mode of administration: push, intermittent, continuous
 - e. Major side effects: gastritis, increased risk for pneumonia and *Clostridium difficile* infection, hypomagnesemia

- f. Nursing considerations: monitor magnesium levels, monitor for increase in bowel movements, drug is incompatible with most other drugs
 - g. Patient/caregiver education: instruct patient to report abdominal pain or increase in bowel movements
 - h. Related drugs: lansoprazole (Prevacid) and esomeprazole sodium (Nexium)
3. Antiemetics
- a. Prototype: metoclopramide hydrochloride (Reglan)
 - 1) Indication: nausea and vomiting (prevention), gastroparesis
 - 2) Usual dosage: 10 mg before each meal and at bedtime
 - 3) Mode of administration: intermittent
 - 4) Major side effects: restlessness, drowsiness, fatigue, lassitude, and extrapyramidal reactions
 - 5) Nursing considerations: too rapid an injection may increase anxiety, monitor for involuntary movements and development of tardive dyskinesia
 - 6) Patient/caregiver education: instruct patient to report involuntary movements
 - b. Ondansetron hydrochloride (Zofran)
 - 1) Indications: nausea and vomiting
 - 2) Usual dosage: varies with clinical indication
 - 3) Mode of administration: push, intermittent
 - 4) Major side effects: headache, diarrhea, or constipation
 - 5) Nursing considerations: inspect vial for precipitate, precipitate can be resolubilized by shaking
 - 6) Patient/caregiver education: instruct patient to report any changes in bowel habits
 - c. Droperidol (Inapsine)
 - 1) Indications: induction of anesthesia; prevention of postoperative nausea and vomiting
 - 2) Usual dosage: 2.5 mg
 - 3) Mode of administration: push
 - 4) Major side effects: QT prolongation, drowsiness, extrapyramidal reactions, and neuroleptic malignant syndrome
 - 5) Nursing considerations: ECG monitoring must be performed before giving droperidol
 - 6) Patient/caregiver education: instruct patient to report abnormal movements

G. Hormone and Synthetic Substitutes

- 1. Insulin (regular)
 - a. Indications: diabetic coma, ketoacidosis, short-term use for the treatment of hyperkalemia
 - b. Usual dosage: based on serum glucose level
 - c. Mode of administration: push, continuous
 - d. Major side effects: nausea, hunger, fatigue, clammy skin, nervousness, sweating, convulsions, and hypokalemia
 - e. Nursing considerations: monitor serum glucose levels
 - f. Patient/caregiver education: instruct patient regarding signs and symptoms of hypoglycemia and hyperglycemia
 - g. Related drug: insulin aspart (Novolog)

2. Antidote: glucagon hydrochloride
 - a. Indications: hypoglycemia
 - b. Usual dose: 1 mg
 - c. Mode of administration: push
 - d. Major side effects: nausea, vomiting, and rash
 - e. Nursing considerations: monitor serum glucose levels
 - f. Patient/caregiver education: instruct patient regarding prevention of hypoglycemia
3. Oxytocic agent: oxytocin (Pitocin)
 - a. Indications: induce or stimulate labor; stimulate postpartum contractions to decrease bleeding
 - b. Usual dosage: varies with clinical indications
 - c. Mode of administration: continuous
 - d. Major side effects
 - 1) maternal: uterine rupture, fluid retention, and bradycardia
 - 2) fetal: CNS damage and arrhythmias
 - e. Nursing considerations: monitor BP, fetal heart, strength and timing of contractions, and fluid intake
 - f. Patient/caregiver education: instruct patient concerning uterine cramping
4. Corticosteroids
 - a. Prototype: hydrocortisone sodium succinate (Solu-Cortef)
 - b. Indications: adrenocortical insufficiency; treatment of autoimmune disorders
 - c. Usual dose: 50 to 100 mg every 6 to 24 hours
 - d. Mode of administration: push, intermittent
 - e. Major side effects: hyperglycemia, sodium retention, nausea, vomiting, insomnia, restlessness
 - f. Nursing considerations: monitor serum glucose levels; requires a taper if used for longer than 7 to 10 days
 - g. Patient/caregiver education: instruct patient regarding restlessness or insomnia
 - h. Related drugs: dexamethasone sodium phosphate (Decadron) and methylprednisolone sodium succinate (Solu-Medrol)

H. Immune Modulator Agents

1. Immunostimulants
 - a. Prototype: immune globulin IV (Gammagard)
 - b. Indications: immunoglobulin G deficiency
 - c. Usual dosage: varies with clinical indication and manufacturer recommendations
 - d. Mode of administration: intermittent
 - e. Major side effects: angioedema, fever, hypotension, erythema, and urticaria
 - f. Nursing considerations: monitor vital signs because agent may cause hypotensive reaction; initiate infusion slowly; emergency equipment should be readily available
 - g. Patient/caregiver education: instruct patient to report any feelings of light-headedness
2. Immunosuppressants
 - a. Prototype: cyclosporine (Sandimmune IV)
 - b. Indications: prevent organ transplant rejection
 - c. Usual dosage: individualized based on indication
 - d. Mode of administration: intermittent

- e. Major side effects: renal dysfunction, hypertension, acne, seizures, diarrhea, gum hyperplasia, headache, hyperkalemia, hyperuricemia, infection, paresthesia, skin rash, tremor, and anaphylaxis
- f. Nursing considerations: monitor BUN, CBC, serum creatinine, bilirubin, and liver enzyme levels; monitor blood drug levels; observe for signs of infection
- g. Patient/caregiver education: instruct patient to report change in temperature and other signs of infection
- h. Related drugs: azathioprine sodium (Imuran) and tacrolimus (Prograf)

I. Respiratory Smooth Muscle Relaxants

- 1. Aminophylline
 - a. Indications: bronchial asthma, reversible bronchospasm of chronic bronchitis or emphysema
 - b. Usual dosage: varies with clinical indication and response
 - c. Mode of administration: intermittent
 - d. Major side effects: nausea, vomiting, delirium, vertigo, anxiety, ventricular fibrillation, palpitations, tachycardia, and headache
 - e. Nursing considerations: avoid rapid administration; monitor serum levels; 500 mg aminophylline is equivalent to 400 mg theophylline; monitor respiratory rate
 - f. Patient/caregiver education: instruct patient to report changes in sensorium
 - g. Related drug: theophylline

J. Vitamins

- 1. Folic acid (Folvite); vitamin B complex
 - a. Indication: megaloblastic and macrocytic anemias of malnutrition
 - b. Usual dosage: 1 mg/day
 - c. Mode of administration: push, intermittent, continuous
 - d. Major side effects: rare
 - e. Nursing considerations: none
 - f. Patient/caregiver education: none
- 2. Multivitamins (M.V.I.-12)
 - a. Indication: vitamin deficiency
 - b. Usual dosage: one 5- to 10-mL dose every 24 hours; varies according to manufacturers' recommendations
 - c. Mode of administration: intermittent, continuous
 - d. Major side effects: rare
 - e. Nursing considerations: never use undiluted; do not use if crystals are present
 - f. Patient/caregiver education: instruct patient regarding vitamin supplementation
- 3. Pyridoxine hydrochloride (Hexa-Betalin)
 - a. Indications: vitamin B₆ deficiency
 - b. Usual dosage: 10 to 100 mg every 24 hours
 - c. Mode of administration: push, continuous
 - d. Major side effects: rare
 - e. Nursing considerations: agent deteriorates when exposed to excessive heat
 - f. Patient/caregiver education: instruct patient to report change in body temperature or flushing

4. Thiamine hydrochloride
 - a. Indication: thiamine deficiency syndromes (beriberi, Wernicke's encephalopathy, peripheral neuritis)
 - b. Usual dosage: varies with clinical indication and response
 - c. Mode of administration: 100 mg or fraction thereof in a 5-minute injection; continuous
 - d. Major side effect: hypersensitivity reaction
 - e. Nursing considerations: none
 - f. Patient/caregiver education: instruct patient to report unusual signs and symptoms
5. Phytonadione (vitamin K₁, Aquamephyton)
 - a. Indications: anticoagulant-induced prothrombin deficiency; hemorrhagic disease of newborn; hypoprothrombinemia resulting from obstructive jaundice, ulcerative colitis, biliary disease
 - b. Usual dose: 1 to 10 mg
 - c. Mode of administration: 1 mg or fraction thereof in a 1-minute injection; continuous
 - d. Major side effects: anaphylaxis
 - e. Nursing considerations: monitor PT; administer with caution because of the potential for anaphylactic reaction
 - f. Patient/caregiver education: instruct patient to report unusual signs and symptoms that could indicate anaphylaxis

K. Bone Resorption Inhibitors

1. Prototype: zoledronic acid (Zometa, Reclast)
2. Indication: prevention and treatment of osteoporosis, management of hypercalcemia of malignancy, and treatment of bone metastases
3. Usual dosage: 4 to 5 mg
4. Mode of administration: intermittent over at least 15 minutes
5. Major side effects: osteonecrosis of the jaw, musculoskeletal pain, and nephrotoxicity
6. Nursing considerations: infuse over at least 15 minutes, monitor urine output and renal function
7. Patient/caregiver education: instruct patient to report decrease in urine output or jaw pain
8. Related drugs: ibandronate (Boniva) and pamidronate (Aredia)

BIBLIOGRAPHY

- Fischbach, F. T. (2009). *A manual of laboratory and diagnostic tests* (8th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.
- Gahart, B. L., & Nazareno, A. R. (2012). *2012 Intravenous medications* (28th ed.). St. Louis, MO: Saunders/Elsevier.
- Gutierrez, K. (2008). *Pharmacotherapeutics: Clinical reasoning in primary care* (2nd ed.). St. Louis, MO: Saunders/Elsevier.
- Infusion Nurses Society. (2011a). *Policies and procedures for infusion nursing* (4th ed.). Norwood, MA: Infusion Nurses Society.
- Infusion Nurses Society. (2011b). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S1–S110.
- McEvoy, G. K. (Ed.). (2012). *AHFS drug information 2012*. Bethesda, MD: American Society of Health System Pharmacists, Inc.

- National Coordinating Council for Medication Error Reporting and Prevention. *What is a medication error?* Retrieved from <http://www.nccmerp.org/aboutMedErrors.html>
- Phillips, L. D. (2010). *Manual of I.V. therapeutics: Evidence-based practice for infusion therapy* (5th ed., pp. 624–695). Philadelphia, PA: F.A. Davis Co.
- Turner, M. S., & Hankins, J. (2010). Pharmacology. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 263–298). St Louis, MO: Saunders/Elsevier.
- Weinstein, S. M. (2007). *Plumer's principles & practice of intravenous therapy* (8th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

Infection Prevention and Control

Mary McGoldrick, MS, RN, CRNI®



I. Epidemiology and Host Defense

A. Overview

1. Epidemiology and host defense are concerned with defining and explaining the interrelationship of the host, agent, and environment in the prevention and control of disease
2. The principles of infection prevention and control provide a foundation for the delivery of infusion therapy
3. Initiation of an intravenous catheter breaks the transcutaneous skin barrier, which is the first line of host defense, and provides an avenue of entry for many of the organisms capable of causing infection

B. Immune System

1. Body mobilizes a complex system of cells and organs called the immune system to neutralize or fight invading pathogens
2. One missing element can cause the entire immune system to be ineffective
3. Leukocytes, or white blood cells, are important components of the immune system
 - a. Normal white blood cell count ranges from 4,500 to 10,000 per cubic millimeter, with neutrophils and lymphocytes comprising 80% to 90% of the total white blood cell count
 - b. There are three types of leukocytes: granulocytes, monocytes, and lymphocytes
 - c. Differential white blood cell count provides more specific information related to infection and disease processes
4. Granulocytes and monocytes are the foundation of the nonspecific immune response
 - a. Granulocytes—divided into three groups: neutrophils, eosinophils, and basophils
 - 1) Neutrophils or polymorphonuclear leukocytes (bands and segments)
 - a) Body's first line of defense and are the first cells to appear in large numbers at the site of infection

- b) Segments are mature neutrophils; bands are less mature neutrophils
- c) Bands and segments are commonly referred to as polymorphonuclear leukocytes and are capable of destroying invading bacteria and viruses
- d) Are the most numerous circulating white blood cells
- e) Rapidly respond to inflammatory and tissue injury sites
- f) Neutropenia is defined as a decrease in the absolute neutrophil count or ANC
- g) An ANC of 1,500 to 2,000 per cubic millimeter places the patient at moderate risk for developing an infection, while an ANC <500 per cubic millimeter places the patient at substantial risk for developing an infection
- h) Other authorities suggest that an ANC of 500 to 1,000 per cubic millimeter places the patient at moderate risk for infection
- 2) Eosinophils
 - a) Increase during allergic reactions and parasitic conditions
 - b) Decrease when steroids are parenterally administered or during periods of stress
- 3) Basophils
 - a) Increase during the healing process
 - b) Decrease when steroids are parenterally administered or during periods of stress
- b. Agranulocytes
 - 1) Monocytes
 - 2) Lymphocytes

C. Nonspecific Immune Response

1. Provided by granulocytes and monocytes
2. Neutrophils and monocytes are macrophages responsible for engulfing and partially digesting or phagocytizing the invading antigens
 - a. Neutrophils (bands and segments) predominate in the first hours of injury
 - b. Monocytes respond late during the acute phase of infection
 - 1) Stronger action than neutrophils
 - 2) Can ingest larger particles of debris

D. Specific Immune Response

1. Formed by the B and T lymphocytes
2. Lymphocytes have specific antigen recognition
 - a. Neutralize bacterial endotoxins
 - b. Phagocytize invading bacteria and viruses
 - c. Increase with the occurrence of chronic and viral infections

E. Bloodstream Infection: Surveillance Definition versus Clinical Definition

1. Catheter-related bloodstream infection (CRBSI)
 - a. Not the same as catheter-associated bloodstream infection (CABSI) or central line-associated bloodstream infection (CLABSI)
 - b. Clinical definition is used when diagnosing and treating patients
 - c. Definition is not typically used for surveillance purposes
 - d. Requires specific laboratory testing that more thoroughly identifies the catheter as the source of the bloodstream infection

- e. Problematic to precisely establish if a bloodstream infection is a CRBSI due to:
 - a. Clinical needs of the patient (e.g., the catheter is not always pulled)
 - b. Limited availability of microbiologic methods (e.g., many labs do not use quantitative blood cultures or differential time to positivity)
 - c. Procedural compliance by direct care personnel (e.g., specimen labeling must be accurate)
- 2. CLABSI
 - a. A term used by the Center for Disease Control and Prevention's (CDC's) National Healthcare Safety Network (NHSN) for surveillance definition
 - b. Surveillance definitions are really definitions for CABSI
 - c. Surveillance definition overestimates the true incidence of CRBSI because:
 - 1) Not all bloodstream infections originate from a catheter
 - 2) Some bloodstream infections are secondary to other sources other than the central line (e.g., pancreatitis, mucositis) that may not be easily recognized

F. Risk Factors for Intravascular CRBSIs

- 1. Immunosuppression and immunodeficiency
- 2. Severe underlying chronic illness
 - a. Diabetes mellitus
 - b. Diseases that cause granulocytopenia
 - c. Other humoral or cellular immune states with neutrophil impairment, increasing a person's susceptibility to infusion-related infection
- 3. Administration of multiple infusions
- 4. Extended hospitalization
- 5. Leukopenia (an abnormal decrease of white blood cells, usually below $5,000/\text{mm}^3$)
- 6. Presence of a concurrent infection
 - a. Urinary tract or respiratory infections
 - b. Hematogenous seeding when microorganisms migrate to the intravascular catheter from distant foci or if a catheter is inserted into a patient with a high-grade bacteremia or fungemia
- 7. Age
 - a. Infants younger than 1 year have an immature immune system
 - b. The older adult population (over 60 years of age) tends to exhibit a hyporesponsiveness to the invasion of foreign antibodies and may not exhibit the same signs and symptoms of infection, making the diagnosis of septicemia difficult
- 8. Burns
- 9. Therapeutic regimens
 - a. Antineoplastic therapy increases the risk of infection due to myelosuppression
 - b. Long-term parenteral nutrition due to the ability of microorganisms to translocate across the gastrointestinal tract into the mesenteric lymph system, spleen, liver, and vasculature
 - c. Corticosteroid therapy depresses the body's immune system and decreases the body's natural response to invading foreign proteins, permitting the invasion and multiplication of microorganisms
 - d. Antibiotic therapy, especially prolonged therapy, alters the body's natural flora and predisposes the body to the development of an infection



II. Means of Contamination

A. Extrinsic Contamination

1. Can occur when microorganisms are introduced into the infusion system by the administration of intravenous fluids
2. Most prevalent means of contamination
3. Primary causes of contamination
 - a. Improper hand hygiene by healthcare personnel
 - b. During compounding of admixtures
 - 1) Improper use of laminar flow hoods
 - 2) Use of malfunctioning laminar flow hoods
 - 3) Incorrect use of admixing equipment, such as needles, syringes, or calibration devices that contaminate products
 - 4) Failure to refrigerate admixed fluid containers
 - c. Improper aseptic technique while inserting a vascular access device (VAD)
 - 1) Improper site preparation
 - 2) Touch contamination of catheter or the prepared insertion site
 - 3) Use of contaminated agents for the preparation of skin
 - 4) Improper application of dressing
 - 5) Failure to replace catheter insertion sites at the first sign of a complication (e.g., erythema, swelling)
 - 6) Allowing a damp, soiled, or nonocclusive dressing to remain on the insertion site
 - d. During infusion system interventions/manipulations
 - 1) Touch contamination of the administration set spike
 - 2) Addition or touch contamination of add-on devices such as filters or extension sets
 - 3) Addition or replacement of administration set(s)
 - 4) During air removal from the administration set
 - 5) Withdrawal of blood for laboratory specimens
 - 6) Accidental disconnection of the administration set
 - 7) Failure to maintain sterile, closed infusion system
 - 8) Use of external devices to calibrate pressure monitoring systems
 - 9) Administrations sets that are left in place too long, including blood administration sets, or residual blood in the administration set, may result in the proliferation of bacteria
 - 10) Damp, soiled, or nonocclusive dressings left in place
 - 11) Ointment at the insertion site (exception: hemodialysis catheters)
 - e. During medication administration
 - 1) When medication is added to parenteral fluids
 - 2) When secondary administration sets are not maintained as a closed system
 - 3) During administration through injection/access ports of administration sets
 - 4) When changing tubing or containers during administration of intermittent medication
 - 5) When multidose vials are used, the potential for contamination increases
4. Primary causative organisms include, but are not limited to, the following:
 - a. Enterobacteriaceae (*Enterobacter cloacae*, *Enterobacter agglomerans*, *Serratia marcescens*, *Klebsiella* species)

- b. *Staphylococcus aureus*
- c. Coagulase-negative staphylococci
- d. Fungi (*Candida*, *Fusarium*, *Trichophyton*, or *Malassizia* species)
- e. *Corynebacterium* species
- f. *Pseudomonas aeruginosa*
- g. *Serratia cepacia*
- 5. Preventive strategies
 - a. Proper hand hygiene
 - b. Proper handling of infusates, including refrigeration when indicated
 - c. Careful examination of infusates
 - d. Careful admixture preparation
 - e. Careful handling of administration sets
 - f. Disinfection of injection ports/needleless connectors prior to each access
 - g. Strict aseptic technique when inserting catheters or changing dressings
 - h. Proper skin preparation of insertion sites
 - i. Remove Peripheral catheter at first sign of complications
 - j. Routine change of dressing, stabilization device, add-on devices, and administration set
 - k. Maintenance of dry, intact dressing on catheter insertion site
 - l. Maintaining a closed infusion system, whenever possible
 - m. Avoiding unnecessary manipulation of the infusion system

B. Intrinsic Contamination

- 1. Occurs during the manufacturing process
 - a. Continuously monitored by industry and regulatory agencies
 - b. Sampling procedures devised to detect ongoing problems result in low levels of contamination
 - c. Sequential sampling procedures to monitor the production process
 - 1) Rejection of products contaminated at unacceptable frequencies
 - 2) Consideration of previous sterility testing results to determine the acceptability of current tests
- 2. Low rate of occurrence
 - a. An epidemic of infusion-related bacteremias possibly related to
 - 1) Mass production of large volumes of intravenous solutions
 - 2) Microorganisms in fluid containers that proliferate during storage
 - b. Nearly all reported septicemias are associated with contaminated infusate by aerobic gram-negative bacilli
 - c. Intrinsic contamination should be suspected in patients exhibiting signs and symptoms of septicemia who have no other apparent focus of infection
- 3. Primary causative organisms include, but are not limited to the following:
 - a. Enterobacteriaceae (*Enterobacter cloacae*, *Enterobacter agglomerans*, *Serratia marcescens*, *Klebsiella* species)
 - b. *Nonaeruginose pseudomonades*, particularly *Pseudomonas cepacia* and *Pseudomonas maltophilia*, or by the *Citrobacter* species
- 4. Preventive strategies
 - a. Stringent quality control during the manufacturing process
 - b. Careful examination of intravenous fluid containers and packaging before use for
 - 1) Puncture holes, cracks, tears, or leaks
 - 2) Apparent moisture
 - 3) Loss of vacuum

- 4) Damage to bag, bottle closures, missing or improperly fitting port covers, protective seals, and coverings
- 5) Beyond-use date or expiration date surpassed
- 6) Clarity and particulate matter
5. Isolation of lot(s) of suspected contaminated products
6. Documentation and reporting mechanisms for contamination
 - a. If potential contamination is suspected, promptly report to:
 - 1) Infusion therapy manager
 - 2) Pharmacist
 - 3) Materials management
 - 4) Risk management
 - 5) Licensed independent practitioner (LIP)
 - b. Immediate notification of authoritative bodies
 - 1) Local, state, and federal authorities
 - 2) CDC
 - 3) Food and Drug Administration (FDA)

C. Exogenous Sources of Contamination

1. Caused by transmission of organisms from sources other than the patient; can be from the healthcare workers' hands, nose, clothing, or other contaminated objects
2. Frequent occurrences
3. Primary causative organisms include, but are not limited to the following:
 - a. *Staphylococcus aureus*
 - b. Coagulase-negative staphylococci
 - c. *Staphylococcus epidermidis*
 - d. *Pseudomonas aeruginosa*
 - e. *Enterococcus*
 - f. *Candida* species
4. Preventive strategies
 - a. Proper hand hygiene
 - b. Strict adherence to aseptic technique
 - c. Use of barrier protection, such as gloves, face masks, and disposable gowns

D. Endogenous Sources of Contamination

1. Caused by patient's own microflora
2. Two sources of endogenous infections
 - a. Primary endogenous infections
 - 1) Caused by the patient's own flora (e.g. placement of a tunneled catheter exit site near a patient's tracheostomy site may result in a catheter infection from migration of the patient's own flora around the tracheostomy)
 - 2) Intravenous catheter can become colonized by microorganisms from a distant site of infection
 - b. Secondary endogenous infections
 - 1) Caused by modification of the patient's own flora following prolonged antibiotic administration
 - 2) Colonization with healthcare setting flora
3. Patients who are immunocompromised are more susceptible

4. Some microorganisms can translocate across the gastrointestinal tract to normally sterile tissues, such as the mesenteric lymph nodes, spleen, liver, and blood
5. A variety of microorganisms associated with the flora of the skin are commonly involved
6. Primary causative organisms include, but are not limited to, the following:
 - a. *Staphylococcus aureus*
 - b. *Staphylococcus epidermidis*
 - c. *Escherichia coli*
 - d. *Candida* species
7. Preventive strategies
 - a. Proper hand hygiene
 - b. Proper site preparation
 - c. Strict adherence to aseptic technique
 - d. Use of appropriate antimicrobial solutions
 - e. Replace or remove peripheral catheter upon first sign of complications
 - f. Proper technique for preparing intravenous sites
 - g. Changing dressings that have become compromised, damp, or soiled
 - h. Proper disinfection of injection ports/needleless connectors and systems connections
 - i. Use of disinfection caps on needleless connectors



III. Microorganisms Commonly Involved in Intravascular Catheter-Related Infections

A. Gram-Negative Bacteria

1. Gram-negative organisms are the most common pathogens found in contaminated infusate
2. *Klebsiella* and *Escherichia coli*, which are primarily transmitted from hand and food contamination; and *Pseudomonas aeruginosa*, recognized by green, foul smelling exudates at the insertion or exit site
3. *Klebsiella* and *Enterobacter aerogenes* exhibit rapid growth in dextrose solutions, whereas *Pseudomonas cepacia*, *Pseudomonas aeruginosa*, and *Serratia* grow in distilled water
4. Saline solutions support the growth of most organisms, but poorly support the growth of *Candida*
5. Crystalline amino acids with 25% dextrose solutions support the growth of *Candida*, although slowly
6. 10% lipid emulsions have been shown to support the rapid growth of *Candida*
7. Blood products
 - a. Contamination of blood products occurs rarely; only 1% to 6% of blood units show small amounts of microorganisms
 - b. Blood and blood products may be contaminated at the collection site, during the actual collection procedure, during the separation process into components, or during transport and storage
 - c. Blood collection sets may be contaminated during the manufacturing process
 - d. Storage time and temperature of the blood or blood products are directly related to the growth of microorganisms

- e. Sepsis from contaminated blood products is related to the endotoxins produced by psychrophilic (or cold-growing) gram-negative bacteria
- f. *Pseudomonas* species, *Citrobacter*, *Freundii*, *Escherichia coli*, and *Yersinia enterocolitica* are the most common pathogens associated with endotoxin production
- g. The resulting transfusion reaction produces overwhelming shock and a high mortality rate because of the massive numbers of pathogens present in the contaminated unit

B. Gram-Positive Bacteria

1. Gram-positive organisms, especially *Staphylococcus aureus* and *Enterococcus*, are the most frequently involved pathogens in catheter-related infections and sepsis
2. Enterococcal infections have become extremely difficult to treat with the emergence of vancomycin-resistant enterococcus
3. *Staphylococcus aureus* is the most common gram-positive organism causing septicemia
4. *Staphylococcus aureus* is carried and transmitted on the hands of healthcare workers or is colonized on the patient's skin, migrating on the catheter surface into the bloodstream at the catheter's insertion site
5. The causal agent in approximately two-thirds of infusion-related infections
6. Attach themselves to the inner and outer surfaces of intravenous catheters, grow and proliferate even in the absence of externally supplied nutrients
7. Produce a glycocalyx solution called slime, which protects the microorganisms by providing resistance to the natural immune mechanisms of the body, and even to prolonged high-dose antibiotic therapy

C. Fungi

1. The most frequently identified pathogen associated with fungemias is *Candida albicans*
2. Central vascular access devices (CVADs) are the most likely sources of this pathogen
3. Focal retinal lesions known as cotton-wool spots are commonly seen in patients with severe *Candida* infections, even without positive blood cultures
4. Careful ophthalmologic examinations should be performed on patients with suspected catheter-related fungemia, especially those patients receiving parenteral nutrition



IV. Catheter-Related Infection

A. Factors Influencing Risk for Developing Catheter-Related Infection

1. Susceptibility to infection
 - a. Leukopenia
 - b. Presence of concurrent infection

- c. Severe underlying chronic illness
 - d. Age
 - e. Burns
2. Method of site preparation
 - a. Not using appropriate antiseptic solutions
 - b. Improper technique
3. Method of insertion
 - a. Technical skill of the clinician placing the venous access device
 - b. Improper aseptic technique during catheter insertion
 - c. Inadequate barrier protection
 - d. Inadvertent contamination
4. Type of catheter and material
 - a. Larger, stiffer catheters provoke thrombogenesis, an inflammatory response, which facilitates colonization
 - b. Polyurethane and silicone catheter materials are softer and less thrombogenic
 - c. *Candida* species and coagulase-negative staphylococcus have been shown to better adhere to catheters made of polyvinylchloride than to those made of polytetrafluoroethylene
 - d. Catheters with silver ion impregnated cuffs have been shown to prevent the migration of bacteria and fungi along the external surface of the catheter, preventing colonization
5. Catheter location
 - a. Peripherally placed access devices pose a substantially lower risk of septicemia than nontunneled CVADs
 - b. Skin of the upper and lower extremities has a lower temperature than the trunk or neck
6. Residual blood left in the infusion system
7. Use of multilumen catheters
 - a. Patients with multilumen catheters are generally sicker, may be receiving parenteral nutrition, may be immunocompromised, will probably have extended hospital stays, and have their infusion systems accessed and manipulated more frequently
8. Fibrin sheaths
 - a. Form within hours after insertion of a catheter
 - b. May be a protective mechanism or may be a nidus for infection
 - c. Promotes bacterial adherence and increases bacterial replication around the catheter
 - d. Formation prevention interventions under investigation include the use of antibiotic locks, prophylactic use of antibiotics, alternative flush solutions, and prophylactic use of thrombolytic drugs
9. Migration of bacteria through the subcutaneous catheter tract
10. Contamination of infusion system
11. Hematogenous seeding from a concurrent source of infection
12. Biofilm attachment and growth to the intravascular portion of the catheter may promote bacterial adherence, replication, and detachment of microbes
13. Longer catheter dwell time may increase colonization of microorganisms
14. Colonization of microorganisms on the catheter hub
15. Long-term antimicrobial therapy alters the normal flora of the skin



V. Contamination at the Insertion Site

A. Predisposing Conditions

1. Colonization of microorganisms at the insertion site is associated with the highest incidence of catheter-related infections
2. Normal skin flora
 - a. Serves as one of the main sources of bacteria responsible for infusion-associated infection and sepsis
 - b. Can colonize on catheter hubs, system connections, and insertion sites, especially if moisture is allowed to accumulate under the site dressing
3. Microorganisms of the skin are classified as either resident (permanent) or transient flora
 - a. Resident flora is referred to as colonizing flora
 - 1) Considered to be permanent residents of the skin
 - 2) Not readily removed by mechanical friction
 - 3) Permanent skin flora organisms include, but are not limited to, the following:
 - a) *Staphylococcus epidermidis*
 - b) *Staphylococcus aureus*
 - c) *Corynebacterium* (commonly referred to as diphtheroids or coryneforms)
 - d) *Klebsiella-Enterobacter* group
 - b. Transient flora is referred to as contaminating or noncolonizing flora
 - 1) Microorganisms not consistently present on most persons
 - 2) Loosely attached to the skin, varying in quantity from day to day
 - 3) Readily transmitted by the hands of healthcare workers
 - 4) Removed when proper hand hygiene is performed

B. Site-Specific Considerations for Reducing the Risk for Infection

1. Peripheral
 - a. Lowest risk of infection with short peripheral catheters, and Teflon or polyurethane peripheral VADs
 - b. Change VAD inserted in an emergency (emergency-inserted catheter) when patient is in stable condition or within 48 hours of catheter insertion; replace with a catheter inserted in a new location
 - c. Appropriate site selection
 - 1) Adults: use an upper extremity site for catheter insertion. Replace a catheter inserted in a lower extremity site to an upper extremity site as soon as possible
 - 2) Pediatric patients: use the upper or lower extremities or the scalp (in neonates or young infants) as the catheter insertion site
 - 3) Avoid the affected arm of a patient who has undergone breast surgery with axillary node dissection, after radiation therapy to that side, with lymphedema, or affected extremity from stroke
 - d. Evaluate the catheter insertion site daily by palpation through the dressing to discern tenderness and by inspection if a transparent dressing is in use
 - 1) Gauze and opaque dressings should not be removed if the patient has no clinical signs of infection
 - 2) If the patient has local tenderness or other signs of possible CRBSI, an opaque dressing should be removed and the site is inspected visually

- e. Remove the peripheral venous catheter if the patient develops signs of phlebitis (warmth, tenderness, erythema, or palpable venous cord) or infection
- 2. Central
 - a. Weigh the risks and benefits of placing a CVAD at a recommended site to reduce infectious complications against the risk for mechanical complications (e.g., pneumothorax, subclavian artery puncture, subclavian vein laceration, subclavian vein stenosis, hemothorax, thrombosis, air embolism, and catheter misplacement)
 - b. Avoid using the femoral vein for central venous access in adult patients
 - c. Use a fistula or graft in patients with chronic renal failure instead of a central venous catheter for permanent access for dialysis
 - d. Use ultrasound guidance to place a CVAD to reduce the number of cannulation attempts and mechanical complications
 - e. Use a CVAD with the minimum number of ports or lumens essential for the management of the patient
 - f. Promptly remove any CVAD that is no longer essential
 - g. Replace the CVAD as soon as possible (i.e., within 48 hours) when adherence to aseptic technique cannot be ensured (i.e., catheters inserted during a medical emergency)
- 3. Subclavian site
 - a. Use a subclavian site, rather than a jugular or a femoral site, in adult patients to minimize the infection risk for nontunneled central venous catheter placement
 - b. Nontunneled subclavian catheters have the highest risk of *Staphylococcus aureus* septicemia
 - c. Warmer core body temperature on the trunk of the body, resulting in greater potential for microbial growth
 - d. Easy to maintain a sterile occlusive dressing
- 4. Internal jugular site
 - a. Difficult to maintain sterile occlusive dressing and stabilize catheter
 - b. Possible limitation of patient mobility and comfort
- 5. Femoral site
 - a. Difficult to maintain sterile occlusive dressing
 - b. Greater amount of colony-forming units (CFUs) is found on the skin
- 6. Arterial
 - a. Peripheral arterial catheter
 - 1) Inflammation at the insertion site
 - 2) Catheter inserted by cutdown
 - b. Pulmonary artery catheter (Swan-Ganz catheter)
 - 1) Length of catheter dwell time
 - 2) Length of time introducer and pressure-monitoring system are in place
- 7. Intraspinal
 - a. Long-term catheters are associated with increased risk for infection
 - b. Failure to maintain sterile occlusive dressing
- 8. Intraventricular: increased risk for infection related to the absence of leukocytes
- 9. Intraosseous
 - a. Risk for osteomyelitis is low
 - b. Intraosseous route is recommended as an interim measure until more appropriate intravenous access can be established

10. Umbilical
 - a. Remove and do not replace umbilical artery catheters if any signs of CRBSI, vascular insufficiency in the lower extremities, or thrombosis are present
 - b. Remove and do not replace umbilical venous catheters if any signs of CRBSI or thrombosis are present
 - c. Do not use topical antibiotic ointment or creams on umbilical catheter insertion sites because of the potential to promote fungal infections and antimicrobial resistance
 - d. Remove umbilical catheters as soon as possible when no longer needed or when any sign of vascular insufficiency to the lower extremities is observed
 - 1) Optimally, umbilical artery catheters should not be left in place >5 days
 - 2) Remove umbilical venous catheters as soon as possible when no longer needed; umbilical venous catheters can be used up to 14 days if managed aseptically



VI. Infection Prevention and Safety Compliance

A. Hand Hygiene

1. Indications for handwashing and hand antisepsis
 - a. Wash hands with either a nonantimicrobial soap and water or an antimicrobial soap and water when hands are visibly dirty, contaminated with proteinaceous material, visibly soiled with blood or other body fluids, or there is an outbreak of Norovirus or *Clostridium difficile*.
 - b. Use an alcohol-based hand rub routinely for decontaminating the hands if the hands are not visibly soiled and/or if there is an outbreak of Norovirus or *Clostridium difficile*.
 - c. Alternatively, wash hands with an antimicrobial soap and water
 - d. Wash hands with a nonantimicrobial soap and water or with an antimicrobial soap and water, before eating and after using a restroom
 - e. Perform hand antisepsis using either antiseptic hand rub or antiseptic hand wash
 - 1) Before having direct contact with patients
 - 2) Before donning sterile gloves when inserting a central intravascular catheter
 - 3) Before inserting peripheral vascular catheters, or other invasive devices that do not require a surgical procedure
 - 4) After contact with a patient's intact skin
 - 5) After contact with body fluids or excretions, mucous membranes, nonintact skin, and wound dressings
 - 6) After removing gloves
 - 7) Before and after palpating catheter insertion sites as well as before and after inserting, replacing, accessing, repairing, or dressing an intravascular catheter
2. Skin care
 - a. Provide healthcare workers with hand lotions or creams to minimize the occurrence of irritant contact dermatitis associated with hand antisepsis or handwashing
 - b. Solicit information from manufacturers regarding any effects that hand lotions, creams, or alcohol-based hand antiseptics may have on the persistent effects of antimicrobial soaps being used by the institution

3. Other aspects of hand hygiene
 - a. Do not wear artificial fingernails or extenders when having direct contact with patients (e.g. those in intensive care units or operating rooms)

B. Maximal Sterile Barrier Precautions

1. Use maximal sterile barrier precautions, including the use of a cap, mask, sterile gown, sterile gloves, and a sterile full body drape, for the insertion of a CVAD or for guidewire exchange
2. Use a sterile sleeve to protect pulmonary artery catheters during insertion

C. Standard Precautions

1. Standard Precautions are used on all patients when there is the potential for exposure to blood, body fluids, and other potentially infectious materials
2. Personal protective equipment (PPE) use involves specialized clothing or equipment worn by staff for protection against potentially infectious materials. The selection of PPE is based on the nature of the patient interaction and potential for exposure to blood, body fluids, or infectious agents
 - a. Gloves
 - 1) Wear clean gloves, rather than sterile gloves, for the insertion of peripheral intravascular catheters, if the access site is not touched after the application of skin antiseptics
 - 2) Wear sterile gloves for the insertion of arterial, central, and midline catheters
 - 3) Use new sterile gloves before handling the new catheter when guidewire exchanges are performed
 - 4) Wear either clean or sterile gloves when changing a site dressing. Do not palpate the insertion site after the application of an antiseptic, unless aseptic technique is maintained or sterile gloves are worn
 - 5) Wear gloves when it can be reasonably anticipated that contact with blood or other potentially infectious materials, mucous membranes, nonintact skin, or potentially contaminated intact skin (e.g., of a patient incontinent of stool or urine) could occur
 - 6) Wear gloves with fit and durability appropriate to the task
 - 7) Wear disposable medical examination gloves for providing direct patient care
 - 8) Wear disposable medical examination gloves or reusable utility gloves for cleaning the environment or medical equipment
 - 9) Remove gloves after contact with a patient and/or the surrounding environment (including medical equipment) using proper technique to prevent hand contamination
 - 10) Do not wear the same pair of gloves for the care of more than one patient
 - 11) Do not wash gloves for the purpose of reuse since this practice has been associated with transmission of pathogens
 - 12) Change gloves during patient care if the hands will move from a contaminated body site (e.g., perineal area) to a clean body site (e.g., face)
 - b. Gowns
 - 1) Wear a gown, that is appropriate to the task, to protect skin and prevent soiling or contamination of clothing during procedures and patient-care activities when contact with blood, body fluids, secretions, or excretions is anticipated

- 2) Wear a gown for direct patient contact if the patient has uncontained secretions or excretions
- 3) Remove the gown and perform hand hygiene before leaving the patient's environment
- 4) Do not reuse gowns, even for repeated contacts with the same patient
- c. Mouth, nose, and eye protection
 - 1) Use PPE to protect the 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
 - a) Select masks, goggles, face shields, and combinations of each according to the need anticipated by the task performed
 - b) Personal eyeglasses and contact lenses are *not* considered adequate eye protection
 - 2) Wear a facemask to perform intrathecal chemotherapy
 - 3) During aerosol-generating procedures (e.g., bronchoscopy, suctioning of the respiratory tract [if not using in-line suction catheters], endotracheal intubation) in patients who are not suspected of being infected with an agent for which respiratory protection is otherwise recommended (e.g. *M. tuberculosis*, severe acute respiratory syndrome (SARS) or hemorrhagic fever viruses), wear one of the following: a face shield that fully covers the front and sides of the face, a mask with attached shield, or a mask and goggles (in addition to gloves and gown)
 - 4) Wear a surgical mask when placing a catheter or injecting material into the spinal canal or subdural space (i.e., during myelograms, lumbar puncture, and spinal or epidural anesthesia)
3. Safe injection practices for the use of needles, cannulas that replace needles, and where applicable, intravenous delivery systems
 - a. Use aseptic technique to avoid contamination of sterile injection equipment
 - b. Do not administer medications from a syringe to multiple patients, even if the needle or cannula on the syringe is changed
 - c. Use fluid infusion and administration sets (i.e., intravenous bags, tubing, and connectors) for one patient only and dispose appropriately after use. Consider a syringe or needle/cannula contaminated once it has been used to enter or connect to a patient's intravenous infusion bag (solution container) or an administration set
 - d. Do not administer medications from single-dose vials or ampoules to multiple patients or combine leftover contents for later use
 - 1) Use vials labeled by the manufacturer as "single dose" or "single use"; clinically, only for one dose for one patient, and then discard after initial entry into the vial for a single patient. These vials contain no preservative or antimicrobial to prevent bacterial contamination
 - 2) In times of critical need, contents from unopened single-dose/single-use vials can be repackaged for multiple patients. However, this should only be performed by qualified healthcare personnel in accordance with standards in United States Pharmacopeia General Chapter 797 "Pharmaceutical Compounding—Sterile Preparations"
 - e. If multidose vials must be used, both the needle or cannula and syringe used to access the multidose vial must be sterile

- f. Do not keep multidose vials in the immediate patient treatment area and store in accordance with the manufacturer's recommendations; discard if sterility is compromised or questionable
- g. Do not use bags or bottles of intravenous solution as a common source of supply for multiple patients

D. Transmission-Based Precautions

1. In addition to Standard Precautions, use transmission-based precautions for patients with documented or suspected infection or colonization with highly transmissible or epidemiologically important pathogens for which additional precautions are needed to prevent transmission
2. Duration of transmission-based precautions (e.g., droplet, contact) is extended for immunosuppressed patients with viral infections due to prolonged shedding of viral agents that may be transmitted to others
3. Contact precautions are implemented for patients with known or suspected infections or evidence of syndromes that represent an increased risk for contact transmission
 - a. Use of PPE
 - 1) Wear gloves when touching the patient's intact skin or surfaces and articles in close proximity to the patient (e.g., medical equipment, bed rails)
 - 2) Don gloves upon entry into the room cubicle, or patient-care environment
 - 3) Wear a gown whenever anticipating that clothing will have direct contact with the patient or potentially contaminated environmental surfaces or equipment in close proximity to the patient. Don gown upon entry into the room cubicle, or patient-care environment. Remove gown and observe hand hygiene before leaving the patient-care environment
 - 4) After gown removal, ensure that clothing and skin do not contact potentially contaminated environmental surfaces that could result in possible transfer of microorganism to other patients or environmental surfaces
 - b. Patient-care equipment and instruments/devices
 - 1) Handle patient-care equipment and instruments/devices according to standard precautions
 - 2) Use disposable noncritical patient-care equipment (e.g., blood pressure cuffs) or implement patient-dedicated use of such equipment. If common use of equipment for multiple patients is unavoidable, clean and disinfect such equipment before use on another patient
 - 3) In *home care settings*, limit the amount of nondisposable patient-care equipment brought into the home of patients on contact precautions.
 - a) Whenever possible, leave patient-care equipment in the home until discharge from home care services
 - b) If noncritical patient-care equipment (e.g., stethoscope) cannot remain in the home, clean and disinfect items before taking them from the home using a low- to intermediate-level disinfectant.
 - c) Alternatively, place contaminated reusable items in a plastic bag for transport and subsequent cleaning and disinfection
4. Droplet precautions are implemented for patients known or suspected to be infected with pathogens transmitted by respiratory droplets (i.e., large-particle droplets >5 microns in size) that are generated by a patient who is coughing, sneezing, or talking
 - a. Use of PPE

5. Airborne precautions are implemented for patients known or suspected to be infected with infectious agents transmitted person-to-person by the airborne route (e.g. *M. tuberculosis*, measles, chickenpox, disseminated herpes zoster)
 - a. Restrict susceptible healthcare personnel from entering the rooms or homes of patients known or suspected to have measles (rubeola), varicella (chickenpox), disseminated zoster, or smallpox if other immune healthcare personnel are available
 - b. Wear a fit-tested NIOSH-approved N95 or higher level respirator for respiratory protection when entering the room or home of a patient when the following diseases are suspected or confirmed:
 - 1) Infectious pulmonary or laryngeal tuberculosis or when infectious tuberculosis skin lesions are present, and procedures that would aerosolize viable organisms (e.g., irrigation, incision, and drainage, whirlpool treatments) are performed
 - 2) Smallpox (vaccinated and unvaccinated). Respiratory protection is recommended for all healthcare personnel, including those with a documented "take" after smallpox vaccination due to the risk of a genetically engineered virus against which the vaccine may not provide protection, or of exposure to a very large viral load (e.g., from high-risk aerosol-generating procedures, immunocompromised patients, hemorrhagic or flat smallpox)
 - c. No recommendation is made regarding the use of PPE by healthcare personnel who are presumed to be immune to measles (rubeola) or varicella-zoster based on the history of disease, vaccine, or serologic testing when caring for an individual with known or suspected measles, chickenpox or disseminated zoster, due to difficulties in establishing definite immunity
 - d. No recommendation is made regarding the type of PPE (i.e., surgical mask or respiratory protection with a N95 or higher respirator) to be worn by susceptible healthcare personnel who must have contact with patients with known or suspected measles, chickenpox, or disseminated herpes zoster

E. Bloodborne Pathogen Exposure Control Plan

1. Required by the Occupational Health and Safety Administration (OSHA), each employer having an employee(s) with occupational exposure will establish a written Exposure Control Plan designed to eliminate or minimize employee exposure
2. The exposure control plan includes the following:
 - a. Exposure determination
 - b. Engineering and work practice controls
 - 1) Engineering and work practice controls will be used to eliminate or minimize employee exposure. Where occupational exposure remains after institution of these controls, PPE will also be used
 - 2) Contaminated needles and other contaminated sharps will not be bent, recapped, or removed. Shearing or breaking of contaminated needles is prohibited
 - 3) Such bending, recapping, or needle removal must be accomplished through the use of a mechanical device or a one-handed technique
 - c. Use of PPE
 - d. Provision of hepatitis B vaccination
 - e. Post-exposure evaluation and follow-up
 - f. Sharps injury log



FIGURE 4-1. Biohazard Symbol.

- g. Training of each employee on occupational exposure and recordkeeping
- h. Labels
 - 1) Warning labels will be affixed to containers of regulated waste, refrigerators, and freezers containing blood or other potentially infectious material; and other containers used to store, transport, or ship blood or other potentially infectious materials. Labels will include the Biohazard symbol (See Figure 4-1)
 - 2) Labels will be fluorescent orange or orange-red or predominantly so, with lettering and symbols in a contrasting color
 - 3) Red bags or red containers may be substituted for labels
 - 4) Containers of blood, blood components, or blood products that are labeled as to their contents and have been released for transfusion or other clinical use are exempted from the labeling requirements
 - 5) Individual containers or other potentially infectious materials that are placed in a labeled container during storage, transport, shipment, or disposal are exempted from the labeling requirement
 - 6) Regulated waste that has been decontaminated need not be labeled or color-coded
- i. Regulated waste
 - 1) Contaminated sharps will be discarded immediately or as soon as feasible in containers that are
 - a) Closable
 - b) Puncture-resistant
 - c) Leakproof on sides and bottom
 - d) Labeled or color-coded
 - 2) During use, containers for contaminated sharps will be
 - a) Easily accessible to personnel and located as close as is feasible to the immediate area where sharps are used or can be reasonably anticipated to be found (e.g., laundries)
 - b) Maintained upright throughout use
 - c) Replaced routinely and not be allowed to overfill beyond two-thirds
 - 3) Disposal of all regulated waste will be in accordance with applicable federal, state, and local regulations



VII. Insertion Site Preparation

A. Hair Removal

1. Excessive hair at the insertion site should be clipped, not shaved
2. Shaving can cause microabrasions, which increase the risk of infection
3. Depilatories are not recommended because of the risk for allergic reactions

4. Surgical clippers with disposable clipper heads are acceptable to prevent cross contamination; clipper heads are to be changed after each patient use

B. Insertion Site Cleansing

1. Infection prevention begins with the preparation of the insertion site
2. Clean intended insertion site with soap and water if the extremity is excessively dirty
3. Prepare the skin by cleaning an area 2 to 4 inches in diameter
4. Cleanse the site with an antimicrobial solution, applied liberally and with friction, for a minimum of 30 seconds
5. Fanning, blowing, or blotting the site is contraindicated
6. Avoid touching the skin after it has been cleaned, unless palpated with sterile gloves

C. Recommended Antimicrobial Preparations

1. General
 - a. Prepare clean skin with an antiseptic (70% alcohol, 1% to 2% tincture of iodine, iodophor [povidone-iodine], or alcoholic chlorhexidine gluconate solution) before peripheral venous catheter insertion
 - b. Prepare clean skin with a >0.5% chlorhexidine preparation with alcohol before central venous catheter and peripheral arterial catheter insertion and during dressing changes. If there is a contraindication to chlorhexidine, tincture of iodine, an iodophor, or 70% alcohol can be used as an alternative
 - c. Antiseptics should be allowed to dry according to the manufacturer's recommendation prior to placing the catheter
2. 70% isopropyl alcohol
 - a. Inexpensive
 - b. Rapidly reduces microbial counts on skin by denaturing the protein
 - c. Apply with friction and until the final applicator is visually clean
 - d. Nonirritating; has low allergic and/or toxic responses
3. Chlorhexidine gluconate
 - a. Available as a hand washing agent, as a hydrophillic polyurethane absorptive foam disc, incorporating sustained release chlorhexidine gluconate for use at the catheter site under transparent dressings, and integrated as a gel pad in a transparent adhesive dressing
 - b. The use of chlorhexidine solution for disinfecting the catheter site before insertion and for post-insertion site care will significantly reduce the incidence of catheter-related infections. Not recommended for infants aged <2 months
 - c. Chemically bonds to the protein in the bacterial cell wall
 - d. A 2% chlorhexidine-based preparation is preferred
 - e. Provides good residual protection against colonization on intact skin, persisting for hours after application
 - f. Maintains its activity in the presence of organic matter
 - g. Apply with gentle friction in back and forth strokes for 30 seconds
4. Iodophor (povidone-iodine)
 - a. Contains iodine complex with a solubilizing agent, such as a surfactant or povidone (forming povidone-iodine)
 - b. Penetrates the cell wall, substituting the microbial contents with free iodine
 - c. Requires approximately 2 minutes of skin contact to allow the release of free iodine

- d. Application of 70% isopropyl alcohol immediately after povidone–iodine preparation negates the effect of the iodophor. Remove dried povidone–iodine with sterile water or normal saline in infants under 2 months of age or pediatric patients with impaired skin integrity
 - e. Able to kill gram-negative and gram-positive organisms, fungi, and yeast
 - f. Rapidly neutralized in the presence of blood, serum, and other protein-rich materials
5. Tincture of iodine
- a. Iodine tincture, essentially iodine topical solution, in which half the water has been replaced with ethyl alcohol
 - b. Combined effect of isopropyl alcohol and iodine and can cause skin irritation
 - c. When tincture of iodine is used for skin antisepsis before catheter insertion, it should be removed with alcohol to prevent skin irritation
 - d. Penetrates the cell wall, substituting the microbial contents with free iodine
 - e. Able to kill gram-negative and gram-positive organisms, fungi, and yeast
 - f. Rapidly neutralized in the presence of blood, serum, and other protein-rich materials
6. Acetone
- a. Cleansing with acetone is associated with an increased potential for local inflammation at the insertion site and increased skin irritation
 - b. Exhibits no decrease in the incidence of catheter-related infection

D. Antimicrobial Application

1. Antimicrobial solutions
 - a. Single-use containers are recommended
 - b. Disinfect clean skin before catheter insertions and during dressing changes
 - 1) Apply generous amounts
 - 2) Allow to air dry
 - 3) Do not fan, blot, or blow on the area
 - 4) Apply until the final applicator is visually clean
2. Antibiotic/antimicrobial ointment
 - a. Do not use topical antibiotic ointment or creams on insertion sites, except for dialysis catheters, because of their potential to promote fungal infections and antimicrobial resistance
 - b. Use povidone–iodine antiseptic ointment or bacitracin/gramicidin/polymyxin B ointment at the hemodialysis catheter exit site after catheter insertion and at the end of each dialysis session only if this ointment does not interact with the material of the hemodialysis catheter as per manufacturers' direction for use



VIII. Catheter Care

A. General Considerations

1. Do not submerge the catheter or catheter site in water. Showering may be permitted if precautions can be taken to reduce the likelihood of introducing organisms into the catheter (e.g., if the catheter and connecting device are protected with an impermeable cover during the shower)

2. Ensure that the product used for catheter site care is compatible with the catheter material

B. Dressings

1. Change dressings on CVAD insertion sites using sterile technique
2. Stabilize the catheter securely to eliminate any to-and-fro motion
 - a. A sutureless device is recommended for VAD stabilization to reduce the risk of infection
3. Only use sterile tape as needed underneath the VAD dressing to stabilize the catheter hub
4. Cover the skin–catheter junction site with sterile gauze or sterile, transparent semipermeable membrane (TSM) dressing
5. Replace TSM dressings used on CVAD sites at least every 7 days, except in those pediatric patients in which the risk for dislodging the catheter may outweigh the benefit of changing the dressing
6. Replace TSM dressings used on tunneled or implanted CVAD sites no more than once per week (unless the dressing is soiled or loose), until the insertion site has healed
7. Change the TSM dressing immediately if it becomes damp, soiled, or loosened
8. Gauze dressing
 - a. Use a gauze dressing if the patient is diaphoretic or if the site is bleeding or oozing, until this is resolved
 - b. Change routinely every 48 hours
 - c. Consider the dressing a gauze dressing if gauze is placed under a TSM dressing. If the gauze is used to support the wings of a noncoring needle in an implanted port and does not obscure the insertion site, it is not considered a gauze dressing
 - d. Tape all edges of the gauze securely if not placed under a TSM dressing
 - e. Change the dressing immediately if the edges are no longer closed or intact, or if the gauze is damp or soiled
9. Use a chlorhexidine-impregnated dressing for temporary short-term CVADs in patients older than 2 months of age if the CLABSI rate is not decreasing despite adherence to basic prevention measures, education, and training, appropriate use of chlorhexidine for skin antisepsis, and maximum sterile barrier

C. Antimicrobial/Antiseptic Impregnated Catheters and Cuffs

1. Use a chlorhexidine/silver sulfadiazine or minocycline/rifampin-impregnated CVAD in patients whose catheter is expected to remain in place >5 days if, after successful implementation of a comprehensive strategy to reduce rates of CLABSI, the CLABSI rate is not decreasing. The comprehensive strategy should include at least the following three components: educating persons who insert and maintain catheters, use of maximal sterile barrier precautions, and a >0.5% chlorhexidine preparation with alcohol for skin antisepsis during central venous catheter insertion

D. Dressing Protocols

1. Specific to the type of VAD
2. Change the TSM dressing on a peripheral short catheter when the catheter is replaced; avoid touch contamination

3. Change the dressing on an implanted port when the noncoring needle is changed; otherwise, a dressing is not required when the port is not accessed

E. Administration Set

1. Change the primary and secondary administration sets used to administer fluids other than lipid, blood, or blood products, no more often than every 96 hours, when administering IV fluids through a peripheral or CVAD
 - a. If the secondary administration set is detached from the primary administration set, the secondary set is considered a primary intermittent set and should be changed every 24 hours
2. Change administration sets whenever the peripheral IV catheter is changed or when a new CVAD is placed
3. Change administration sets used for parenteral nutrition containing lipids (those combined with amino acids and glucose in a three-in-one admixture or infused separately) every 24 hours
4. Change blood and blood product administration sets after each unit infused or within 4 hours
5. Immediately change the entire system if the integrity of the administration set or solution container is compromised during the infusion
6. Replace administration set used to administer propofol infusions every 6 or 12 hours, when the vial is changed, and per manufacturers' recommendation

F. Needleless Systems

1. Change the needleless components at least as frequently as the administration set. There is no benefit to changing these more frequently than every 72 hours
2. Change needleless connectors no more frequently than every 72 hours or according to manufacturers' recommendations for the purpose of reducing infection rates
3. Ensure that all components of the system are compatible to minimize leaks and breaks in the system
4. Minimize contamination risk by scrubbing the access port with an appropriate antiseptic (chlorhexidine, povidone-iodine, or 70% alcohol) and accessing the port only with sterile devices
5. Use a needleless system to access the administration set
6. When needleless systems are used, a split septum valve may be preferred over some mechanical valves due to increased risk of infection with the mechanical valves
7. Consider the use of an alcohol-impregnated disinfection cap for protecting access ports and catheter hubs in preventing intraluminal contamination and infection

G. Filters

1. Used for the delivery of infusion therapy for those solutions requiring filtration
2. Unless contraindicated because of incompatibility with the plasticizer used in the filter material, use filters designed for small drug volume, or retention of the drug on the filter material
3. Use special blood and blood component filter sets for transfusion therapy

H. Evaluation of VAD Insertion Site

1. Monitor the catheter insertion site visually when changing the dressing or by palpation through an intact dressing on a regular basis, depending on the clinical situation of the individual patient. If patients have tenderness at the insertion site, fever without obvious source, or other manifestations suggesting local or bloodstream infection, the dressing should be removed to allow thorough examination of the site
2. Frequency
 - a. At the time of each dressing change
 - b. Before removal of the catheter
 - c. At regular intervals as established in organizational policies and procedures
 - d. Varies according to
 - 1) The type of VAD
 - 2) Therapy being administered
 - 3) Patient's age and condition
 - 4) Practice setting
3. Assessment parameters include, but are not limited to, indications of
 - a. Infiltration
 - b. Phlebitis
 - c. Infection
 - d. Occlusion
4. Teach patients to self-assess their site and report any changes in their catheter site or any new discomfort
5. Encourage all patients to use a 2% chlorhexidine wash for daily skin cleansing to reduce the incidence of CRBSI



IX. Prevention of Catheter-Related Infections

A. Recommendations

1. Establish intravascular catheter care policies and procedures based on specific recommendations
 - a. *The Infusion Nursing Standards of Practice* (Infusion Nurses Society, 2011c)
 - b. *Guidelines for Prevention of Intravascular Catheter-Related Infections* (O'Grady et al., 2011)
2. Educate healthcare personnel regarding the indications for intravascular catheter use, proper procedures for the insertion and maintenance of intravascular catheters, and appropriate infection prevention measures to prevent intravascular catheter-related infections
3. Periodically assess the knowledge of and adherence to guidelines for all personnel involved in the insertion and maintenance of intravascular catheters
4. Designate only trained personnel who demonstrate competence for the insertion and maintenance of peripheral and central intravascular catheters
5. Ensure appropriate nursing staff levels in intensive care units. Observational studies suggest that a higher proportion of "pool nurses" or an elevated patient-to-nurse ratio is associated with CRBSI in intensive care units where nurses are managing patients with central venous catheters

B. Nursing Considerations

1. Perform stringent hand hygiene
2. Adhere to the principles of aseptic and sterile technique
3. Use maximum sterile barriers (hair cover, mask, sterile gloves, gown, and wide sterile draping) during the insertion of CVADs or catheters with extended dwell times
4. Carefully inspect all equipment before use
5. Maintain a sterile, dry, and intact dressing on the catheter insertion site
6. Establish routine inspections to evaluate the catheter insertion site daily (when possible) by palpation through the dressing to discern tenderness and by inspection if a transparent dressing is in use
 - a. Gauze and opaque dressings should not be removed if the patient has no clinical signs of infection
 - b. If the patient has local tenderness or other signs of possible CRBSI, an opaque dressing should be removed and the site is inspected visually
7. Schedule routine dressing changes of catheter insertion sites
8. Designate a time interval for replacing peripheral catheter site
9. Maintain a closed sterile infusion administration system
 - a. Limit tubing connections
 - b. Use connections with luer-lock design
 - c. Reduce manipulation of the system
10. Follow pharmacy-directed admixture program
11. Extend the expiration time of medications and solutions beyond 24 hours only when the following conditions are met:
 - a. Strict aseptic technique is used during initial infusion system setup
 - b. A closed infusion administration system without injection ports or add-on devices is used
 - c. No violation in the administration system is documented
 - d. Prescribed medications and solutions are stable for the anticipated administration time
12. Complete lipid-containing parenteral nutrition within 24 hours of hanging the solution; complete infusion of blood products within 4 hours

C. Peripheral Arterial Catheters and Pressure-Monitoring Devices for Adult and Pediatric Patients

1. In adults, use of the radial, brachial, or dorsalis pedis sites is preferred over the femoral or axillary sites of insertion to reduce the risk of infection
2. In children, the brachial site should not be used. The radial, dorsalis pedis, and posterior tibial sites are preferred over the femoral or axillary sites of insertion
3. A minimum of a cap, mask, sterile gloves, and a small sterile fenestrated drape should be used during peripheral arterial catheter insertion
4. During axillary or femoral artery catheter insertion, maximal sterile barriers precautions should be used
5. Replace arterial catheters only when there is a clinical indication
6. Remove the arterial catheter as soon as it is no longer needed
7. Use disposable, rather than reusable, transducer assemblies when possible
8. Do not routinely replace arterial catheters to prevent catheter-related infections
9. Replace disposable or reusable transducers at 96-hour intervals. Replace other components of the system (including the tubing, continuous-flush device, and flush solution) at the time the transducer is replaced

10. Keep all components of the pressure-monitoring system (including calibration devices and flush solution) sterile
11. Minimize the number of manipulations of and entries into the pressure-monitoring system. Use a closed flush system (i.e., continuous flush), rather than an open system (i.e., one that requires a syringe and stopcock), to maintain the patency of the pressure-monitoring catheters
12. When the pressure-monitoring system is accessed through a diaphragm, rather than a stopcock, scrub the diaphragm with an appropriate antiseptic before accessing the system
13. Sterilize reusable transducers according to the manufacturers' directions for use, if the use of disposable transducers is not feasible



X. Infectious Complications of Infusion Therapy

A. Phlebitis

1. Phlebitis is a commonly reported complication of infusion therapy and possible precursor to sepsis
2. Inflammation of the tunica intima of the vein with a bacterial infection; use a standardized measurement scale for phlebitis
3. Classify phlebitis according to causative factors which can be chemical, mechanical, bacterial, or post-infusion
4. Risk factors contributing to bacterial phlebitis include
 - a. Poor hand hygiene technique
 - b. Failure to check equipment for compromised integrity
 - c. Poor aseptic technique in preparation of the venipuncture site or infusion system
 - d. Poor catheter insertion technique
 - e. Poorly secured catheter
 - f. Extended catheter dwell time
 - g. Infrequent site observation with failure to notice early signs of phlebitis
5. Causes of bacterial or septic phlebitis
 - a. Improper hand hygiene
 - b. Contamination during admixture of solution or medications
 - c. Improper venipuncture site preparation
 - d. Inadequate catheter insertion techniques
 - e. Poorly secured catheters
 - f. Extended catheter dwell times
 - g. Improper cleansing of injection sites before medication administration
 - h. Frequent entries into the administration system
 - i. Contamination during the manufacturing process
 - j. Failure to inspect solution containers for cracks, leaks, and compromised integrity
 - k. Noncompliance with established recommendations for changing administration equipment
 - l. Infrequent site observation with failure to identify early signs of phlebitis
6. Preventive measures for bacterial phlebitis
 - a. Check insertion site frequently and change at the first sign of tenderness, drainage, or inflammation
 - b. Perform proper hand hygiene

- c. Adhere to aseptic technique, avoiding touch contamination
- d. Replace the peripheral catheter in the opposite extremity; otherwise, reinsert in the same extremity proximal to the previous site
- e. Replace midline catheters only when there is a specific indication
- f. Use a 0.2 micron air-eliminating, bacteria-retentive in-line filter for nonlipid-containing solutions that require filtration

B. Purulent Thrombophlebitis

1. Intravascular thrombus surrounding a catheter becomes infected, producing suppurative or purulent thrombophlebitis
2. Intima is injured, interrupting the integrity of the endothelial cells at the point where the catheter tip touches the vein wall, platelets adhere to the injured wall, and a thrombus, or clot, forms
3. Vein becomes an intravascular abscess, seeding microorganisms into the bloodstream even after the catheter is removed
4. Septicemia can occur and is often difficult to treat
5. *Staphylococcus aureus* and *Candida* are the most frequently cultured organisms
6. Signs and symptoms of this complication are the same as for other septicemias; however, the symptoms may persist even after the infected catheter is removed
7. If untreated, vein will become sclerosed, will not be able to be used for future therapy, and may require surgical intervention
8. Treatment
 - a. Discontinue the catheter and infusion immediately when purulent thrombophlebitis is identified, and notify the LIP
 - b. Culture the catheter using a semi-quantitative method, and culture the drainage at the site prior to cleansing the skin
 - c. Apply cold compresses to the site initially to decrease blood flow and increase platelet aggregation to the already formed clot
 - d. Apply warm compresses after the cold compresses and elevate the extremity
 - e. Avoid massaging the extremity to prevent mobilization of the thrombus, and monitor for further complications

C. Localized Inflammation at the Insertion Site

1. Redness
2. Edema
3. Tenderness
4. Purulent drainage at the insertion or exit site, tunnel, or portal pocket
5. Fever
6. Leukocytosis

D. Cellulitis

1. Acute inflammatory reaction of the skin characterized by localized pain, erythema, swelling, and heat
2. Remove the catheter and monitor the patient for development of other complications such as infection
3. Apply thermal compresses and elevate the affected extremity

E. Pyrogenic Reactions

1. Occurs from infusion of a contaminated infusate in a patient who previously had no signs or symptoms of infection
2. Characteristic symptoms include backache, headache, nausea and vomiting, malaise, shaking chills, and fever
3. Initial signs are similar to Gram-negative sepsis and the differential diagnosis is difficult
4. Most pyrogenic reactions are not associated with bacteremia, and the earlier described signs and symptoms should abate within a few hours after discontinuing the infusion
5. Suspect bacteremia when pyrogenic reactions persist

F. Bacteremia

1. Occurs when bacteria colonizes the skin around the catheter insertion site, migrates along the surface of the catheter, and enters the bloodstream to cause a bloodstream infection
2. Considered catheter-related when the same microorganisms are isolated from both the catheter surface and the blood
3. Bloodstream infection is identified by positive blood cultures
 - a. Primary bacteremia
 - 1) Absence of other sources, such as kidney, respiratory, or wound infections
 - 2) Usually associated with VAD
 - b. Secondary bacteremia
 - 1) Developed from an existing site of infection, such as pneumonia or urinary tract infection
 - 2) Increased risk for patients with burns, cardiovascular infection, or intra-abdominal wound infections
4. Clinical manifestation
 - a. Fever
 - b. Chills
 - c. Hypotension

G. Septicemia

1. Systemic infection in the circulating blood caused by the presence of pathogenic microorganisms or their toxins in the body
2. Difficult to interpret current data
 - a. Many cases of sepsis go unreported
 - b. Frequently, appropriate cultures of blood, cannula, and parenteral fluids are not obtained
3. Considered catheter-related when the source of the infection is identified as the indwelling VAD
4. Defined as catheter-related with a positive semiquantitative culture of >15 CFUs and a positive blood culture for the same organism
5. Septicemia from intrinsically contaminated infusate is indistinguishable from septicemia caused by an extrinsic source; identification is facilitated with the presentation of signs/symptoms
 - a. Occurs within a few hours after initiation of parenteral fluids
 - b. Occurs in a patient in stable condition without underlying causes

6. Septicemia caused by extrinsic contamination may produce an elevated temperature and elevated white blood cell count. Other symptoms include chills, tremors, nausea and vomiting, confusion, seizures, hyperventilation, and if not detected or treated promptly, respiratory failure, vascular collapse, and death



XI. Diagnostic Methods

A. Gram-Stained Culture

1. Perform if drainage can be expressed from the insertion site

B. Semiquantitative Culture

1. Recommended method for culturing
2. Culture purulent drainage prior to cleansing the skin
3. Thoroughly cleanse the site with 70% isopropyl alcohol and allow to air dry
 - a. Use alcohol rather than an antiseptic that contains residual antimicrobial activity as it may kill organisms on the catheter as it is removed
4. After the catheter is removed, 5 cm of the tip and a catheter segment beginning 1 to 2 mm inside the skin–catheter junction are clipped using sterile scissors and placed in sterile tubes or cups
5. For short indwelling catheters, the entire length of the catheter from the skin–junction site is cut with sterile scissors into a sterile specimen container. If possible, restart the peripheral IV in the opposite extremity
6. For CVADs, a 2-inch segment of the catheter tip and intracutaneous segment are cut with sterile scissors and placed in two separate sterile specimen containers
7. Aspirate a sample of fluid from the catheter to reliably diagnose infection caused by contaminated infusate or parenteral nutrition; needs to be cultured quantitatively
8. Semiquantitative culture results indicate infection
 - a. Less than 15 CFUs is considered skin contamination
 - b. Fifteen or more CFUs confirm the presence of a local-related infection
 - c. Correlation with positive blood cultures indicates a catheter-related infection
 - d. In systemic fungal infections, blood cultures may be negative and the catheter tip positive

C. Quantitative Culture

1. Useful in determining if infection is intravascular catheter-related
2. Blood cultures are drawn peripherally from two separate sites
3. To rule out central catheter-related infection, one set of cultures is drawn peripherally and one set is drawn through the catheter
4. The concentration of organisms in the catheter is compared with the peripheral sample
5. Results showing at least a 5- to 10-fold greater increase in concentration of organisms in the catheter blood sample than in the peripheral blood sample are considered significant for catheter-related infection; catheter removal is necessary

D. Parenteral Solution

1. Culture of parenteral fluid, solution container, administration set, and blood
2. Sample of fluid is aspirated from the administration set and cultured quantitatively
3. Discard the entire administration set and solution, and a new system is utilized

E. Blood Cultures

1. Isolate common skin contaminant pathogens
2. Identify the source of organisms
3. When central VADs are suspected of causing infection, draw blood cultures through the catheter and from a peripheral site
4. Isolate blood into aerobic and anaerobic media
 - a. Do not use prep pads containing betadine or chlorhexidine gluconate to wipe off the septum of the blood culture bottles; use alcohol only
5. Obtain blood cultures immediately before a dose is due if the patient is receiving antimicrobial therapy, possibly providing a higher yield
6. If both central and peripheral blood cultures are positive, a diagnosis of CRBSI can be made
7. Volume of blood crucial to maximize the yield of cultures for diagnosis
 - a. In adults, a minimum of 20 mL, with ideally 30 mL per drawing, significantly improves the culture yield, and will identify 99% of the detectable bacteria
8. If recent blood cultures have been positive, it is strongly recommended not to replace the catheter over a guidewire

F. Catheter

1. Perform a semiquantitative culture of the catheter tip
2. Obtain blood cultures with a LIP's order

G. Site Drainage

1. Perform a swab culture of the drainage
2. Obtain a Gram's stain



XII. Antimicrobial Treatment of Intravascular Catheter-Related Infections

A. General Considerations

1. Do not administer systemic antimicrobial prophylaxis routinely before insertion or during the use of an intravascular catheter to prevent catheter colonization or CRBSI
2. Use prophylactic antimicrobial lock solution in patients with long-term catheters who have a history of multiple CRBSI despite optimal maximal adherence to aseptic technique
3. Do not routinely use anticoagulant therapy to reduce the risk of catheter-related infection in general patient populations

B. Host Factors Affecting Selection

1. Pre-existing clinical disease states
2. Renal function
3. Liver function
4. Sites of infection
5. Age
6. Immune status

C. Drug Factors Affecting Selection

1. Toxicity
2. Drug interactions
3. Compatibilities
4. Cost
5. Pharmacokinetics
 - a. Dose
 - b. Route
 - c. Frequency
 - 1) Intermittent administration of drugs results in fluctuating blood concentration levels
 - 2) Drug concentration levels are monitored by laboratory analysis
 - a) Maximum level (peak) is obtained just after a dose is administered
 - b) Lowest level (trough) is obtained just before a dose is administered

BIBLIOGRAPHY

- Centers for Disease Control and Prevention. (2002). Guideline for hand hygiene in health-care settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Morbidity and Mortality Weekly Report*, 51(RR-16), 1–44.
- Infusion Nurses Society. (2011a). *CRNI® Examination Preparation Program* [DVD]. Norwood, MA: Author.
- Infusion Nurses Society. (2011b). *Policies and procedures for infusion nursing* (4th ed.). Norwood, MA: Author.
- Infusion Nurses Society. (2011c). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S1–S110.
- McGoldrick, M. (2010). Infection prevention and control. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 205–228). St Louis, MO: Saunders/Elsevier.
- Occupational Safety and Health Administration. (2000). *Needlestick safety and prevention act of 2000*, November, Pub. No. 106-430, 114 Stat. 1901.
- Occupational Safety and Health Administration. (1991). *Occupational safe exposure to bloodborne pathogens: Final rule*. Washington, DC: Department of Labor, Docket No. H-370.
- O'Grady, N. P., Alexander, M., Burns, L. A., Dellinger, E. P., Garland, J., Heard, S. O., & Healthcare Infection Control Practices Advisory Committee. (2011). Guidelines for the prevention of intravascular catheter-related infections. *American Journal of Infection Control*, 39(4 Supplement 1), S1–S34. doi: 10.1016/j.ajic.2011.01.003.
- Siegel, J. D., Rhinehart, E., Jackson, M., Chiarello, L., & the Healthcare Infection Control Practices Advisory Committee. (2007). *Guidelines for isolation precautions: Preventing transmission of infectious agents in healthcare settings*. Retrieved from <http://www.cdc.gov/hicpac/2007ip/2007isolationprecautions.html>.
- Sweet, M. A., Cumpston, A. C., Briggs, F., Craig, M., & Hamadani, M. (2012). Impact of alcohol-impregnated port protectors and needleless neutral pressure connectors on central-line associated bloodstream infections and contamination of blood cultures in an inpatient oncology unit. *American Journal of Infection Control*, 40(10), 931–934. doi: 10.1016/j.ajic.2012.01.025.
- Wright, M. O., Tropp, J., Schora, D. M., Dillon-Grant, M., Peterson, K., Boehm, S.,...& Peterson, L. R. (2013). Continuous passive disinfection of catheter hubs prevents contamination and bloodstream infection. *American Journal of Infection Control*, 41(1), 33–38. doi: 10.1016/j.ajic.2012.05.030.

Pediatrics

Darcy Doellman, MSN, RN, CRNI®, VA-BC



I. Growth and Development

A. Physiologic Development

1. Premature neonate (<37 weeks gestation at delivery; also called preterm or premature infant)
 - a. Body water content: ratio of fluid to body mass is greater
 - 1) Total body water (TBW) distribution is quantitatively and qualitatively different
 - a) Rapid changes take place at birth
 - b) Thin layer of subcutaneous fat; special care is needed to prevent insensible water losses
 - 2) By 24 weeks of gestation, the TBW of a fetus is approximately 90%; by 32 weeks it is 80%
 - a) TBW and extracellular fluid (ECF) are larger at younger gestational ages
 - b) With continued growth and development, the proportion of ECF decreases as the intracellular fluid (ICF) increases
 - 3) Water requirements vary with birth weight, age, and disease process
 - b. Body surface area (BSA)
 - 1) Approximately two times greater than body weight (BW)
 - 2) Higher BSA: body mass may cause very high insensible water losses that affect fluid balance
 - c. Acid–base regulation
 - 1) Significantly larger BSA affects the route of metabolism by increasing the production of metabolic waste that must be excreted by the kidneys
 - 2) Buffers help to maintain a constant pH by removing or releasing hydrogen ions
 - 3) Buffers act immediately to correct an abnormal pH
 - a) Premature neonates have less homeostatic buffering mechanisms
 - b) Bicarbonate deficit (a slightly lower pH at 7.30 to 7.35) is more common because of high metabolic acid production and renal immaturity (metabolic acidosis)

- d. Renal function
 - 1) Kidneys are functionally immature
 - 2) Inefficient in ability to maintain fluid balance, excrete metabolic products, concentrate or dilute urine, retain or excrete sodium, and acidify urine
 - e. Integumentary system
 - 1) Stratum corneum is underdeveloped; skin is thin and fragile
 - a) Transepidermal water loss may be significant
 - b) Increased permeability and absorption of topically applied substances
 - c) Agents applied to the skin are readily absorbed and may be toxic; avoid the use of solvents and bonding agents, remove preparation agent with sterile water or saline once the procedure is complete
 - d) Avoid the use of isopropyl alcohol for cutaneous antisepsis; associated with chemical burns in preterm neonates
 - 2) Dermal instability (less collagen and fewer elastic fibers) allows fluid accumulation, edema
 - 3) Diminished cohesion between dermis and epidermis; prone to epidermal stripping with tape removal; use tape sparingly
 - f. Hepatic function
 - 1) Liver immature in ability to function, secrete bile, and conjugate bilirubin
 - 2) Affects the ability to metabolize drugs and vitamins; formation of plasma proteins and ketones; storage of glycogen; and capacity to break down amino acids
 - g. Thermoregulation system
 - 1) Incapable of maintaining thermal stability
 - 2) Decreased ability to produce heat, and limited energy and heat stores
 - 3) Changes in temperature result in physiologic stress
 - 4) Hyper/hypothermia may be life-threatening
 - 5) Healthcare professionals should work to maintain a neutral thermal environment, including the use of radiant warmers, isolettes, heat lamps, chemical mattresses, and hats
 - h. Electrolyte balance
 - 1) The regulation of fluid volume and solute concentration (electrolytes) are interrelated
 - 2) Plasma sodium concentration is higher, it decreases with age
 - 3) Potassium concentration is higher during first few months of life than at any other time, as is plasma chloride concentration
 - 4) Low magnesium and calcium levels
 - a) Inability of premature neonate to regulate calcium, combined with high level of serum phosphate (6.5 to 7.5 mg/dL), may contribute to hypocalcemia-associated tetany
 - b) This condition may be associated with an immature parathyroid or vitamin D deficiency
2. Neonate (term infant at birth to 28 days)
- a. Body water content
 - 1) TBW estimated to be approximately 70% to 80% of BW by term
 - 2) Largest proportion of body water (40% to 50%) contained in the ECF compartment
 - 3) Circulating blood volume is approximately 85 to 90 mL/kg of BW

- b. BSA
 - 1) Estimated to be two times as great as that of an adult
 - 2) Gastrointestinal membranes remain larger in proportion to those of an adult
- c. Acid-base regulation: immature renal function and high metabolic acid production cause a tendency toward mild acidosis (pH 7.30 to 7.35)
- d. Renal function: immature and inefficient kidneys lead to excretion of larger quantities of solute-free water than those found in older pediatric patients
- e. Integumentary system: barrier function of the full-term infant is mature
- f. Hepatic function: similar to that of the premature neonate
- g. Thermoregulation
 - 1) Healthy full-term neonates are capable of limited heat production to meet normal heat energy needs
 - 2) Certain factors, such as stress, hypoxia, hypoglycemia, sepsis, and BW, may limit the ability to thermally self-regulate
 - 3) Heat production gradually improves with age and initiation of feedings
- h. Electrolyte balance: similar to that of the premature neonate
- 3. Infant (1 month to 1 year)
 - a. Body water content
 - 1) TBW approximately 75%
 - 2) During the first year, the percentage of ECF decreases from 45% to 27%
 - 3) In one day, as much as one-half of ECF is exchanged through urine output, respiration, and heat loss
 - 4) At approximately 3 months, blood volume is 75 to 80 mL/kg BW
 - b. BSA
 - 1) Remains proportionately larger than that of an adult
 - 2) More vulnerable to fluid balance disturbances
 - c. Acid-base regulation: pH within the normal range (7.35 to 7.45)
 - d. Renal function
 - 1) Remains immature and inefficient
 - 2) Vulnerable to any change in fluid status because of limited ability to respond and regulate fluid and solutes
 - e. Hepatic function: remains immature
 - f. Electrolyte balance
 - 1) Serum phosphate slightly greater than that of the adult
 - 2) Other electrolyte concentrations are within the normal adult ranges
- 4. Toddler (1 to 3 years)
 - a. Body water content
 - 1) After first year, TBW content is approximately 64%
 - a) 34% in the ICF compartment
 - b) 30% in the ECF compartment
 - 2) By the end of the second year, TBW approaches the adult percentage of approximately 60%
 - a) 36% in the ICF compartment
 - b) 24% in the ECF compartment
 - 3) Blood volume of 70 to 75 mL/kg (approximately equal to that of an adult)
 - b. BSA: by the end of the third year, approaches proportions similar to those of an adult
 - c. Acid-base regulation: pH within the normal range
 - d. Renal function: reaches full maturity at the end of the second year

- e. Electrolyte balance
 - 1) Serum phosphate level remains slightly above that of the adult
 - 2) Other electrolyte concentrations are within the normal adult ranges
- 5. Preschool (3 to 6 years)
 - a. Body water content
 - 1) TBW is 60%, equal to that of an adult
 - a) 36% in the ICF compartment
 - b) 24% in the ECF compartment
 - 2) Blood volume is approximately equal to that of an adult
 - b. BSA: proportionally equal to that of an adult
 - c. Acid–base regulation: pH within the normal range
 - d. Renal function: mature kidney function
 - e. Electrolyte balance
 - 1) Serum phosphate level remains slightly above that of the adult until approximately age 5 years
 - 2) Other electrolyte concentrations within normal adult ranges
- 6. School age (6 to 12 years)
 - a. Body water content
 - 1) TBW is 60% and equal between males and females until puberty
 - 2) Blood volume is approximately equal to that of an adult
 - b. BSA: proportionally equal to that of an adult
 - c. Acid–base regulation: pH within the normal range
 - d. Renal function: mature kidney function
 - e. Electrolyte balance: serum levels within normal adult ranges
- 7. Adolescent (12 to 18 years)
 - a. Body water content
 - 1) From puberty to maturity, percentage of TBW is somewhat higher in the male (60%) than in the female (52%)
 - 2) Probably the result of differences in body composition, particularly fat and muscle content
 - 3) Like adults, the ICF comprises 40% to 50% of the total BW, and the ECF comprises 20% to 30% of the total BW
 - 4) Blood volume is 65 to 70 mL/kg (equal to that of an adult)
 - b. BSA: equal to that of an adult
 - c. Acid–base regulation: pH within the normal range
 - d. Renal function: mature kidney function
 - e. Electrolyte balance: serum levels within normal adult ranges

B. Psychosocial Development

- 1. Premature neonate/neonate
 - a. Response to stress
 - 1) Increased oxygen consumption
 - 2) Apnea or bradycardia
 - 3) Hyper/hypoglycemia
 - 4) Vasoconstriction
 - 5) Changes in heart rate, blood pressure (BP), and cerebral blood flow
 - b. Preparation for procedures
 - 1) Use developmentally supportive measures to minimize stress, such as a pacifier, talking softly, swaddling, or avoiding sudden moves
 - 2) Enlist additional help for procedure (positioning and holding)
 - 3) Employ measures to maintain thermal stability

- 4) Assess and manage pain
 - 5) Time procedures before feedings or sufficiently after feedings to minimize the risk of vomiting and aspiration
2. Infant
- a. Social and emotional needs
 - 1) A sense of trust (or mistrust) develops
 - 2) Major fears are separation and stranger anxiety
 - 3) Pleasure is desired and unpleasant situations are avoided, if possible
 - 4) Communicates by crying
 - 5) Response to pain is similar to that of a neonate
 - a) At approximately 3 to 6 months, able to localize pain and purposefully withdraw the extremity
 - b) At approximately 6 months, a response to pain is influenced by the recall of past painful experiences associated with objects or persons
 - b. Preparation for procedures
 - 1) Implement same approaches as those used for neonate
 - 2) Response to procedures is related to separation from the primary caregiver; allow parent/caregiver to remain during procedure, if possible
 - 3) Perform invasive or painful procedures in a separate "safe" room, not in a crib (or bed)
 - 4) Keep harmful objects out of reach
 - 5) Comfort and cuddle infants after procedures
3. Toddler
- a. Social and emotional needs
 - 1) Major fears are separation anxiety (from parents or primary caregivers viewed as their protectors) and loss of control
 - 2) May calm with security items such as pacifier, blanket, and stuffed animal
 - 3) Egocentric (inability to recognize views of others), use magical thinking, and have little concept of time or body integrity
 - 4) Has little concept of cause and effect
 - 5) Increasingly mobile and striving for independence
 - b. Preparation for procedures
 - 1) Understand that toddlers can be very strong and resistant to procedures
 - 2) Just before procedures, briefly and simply explain what they will see, hear, taste, smell, and feel using a positive, firm, and direct approach
 - 3) Allow the toddler to play with equipment or role play with a doll
 - 4) Explain the aspects of the procedure that will require cooperation, use distraction or diversion techniques during the procedure
 - 5) Encourage the presence of a parent/caregiver during the procedure, if possible
 - 6) Support child during the procedure with verbal and touch stimulation; give permission to cry, yell, or use other means to verbally express discomfort
 - 7) Always be honest and never tell a child the procedure will not hurt when it will
 - 8) Contain or use a comfort hold as necessary and use more than one assistant
 - 9) Provide a reward or surprise after the procedure to end the experience on a positive note

4. Preschooler
 - a. Social and emotional needs
 - 1) Major fears are bodily injury and mutilation, loss of control, fear of the unknown, the dark, or being left alone
 - 2) Developing a sense of initiative and desire to please people
 - 3) Difficulty differentiating a "good" hurt (beneficial treatment) from a "bad" hurt (illness or injury)
 - 4) Beginning to view themselves separately from their parents
 - b. Preparation for procedures
 - 1) Implement same approaches as for toddler
 - 2) Involve in care and give choices when possible, but avoid excessive delays
 - 3) Explain why procedures are performed
 - 4) Reassure child that he or she has not done anything wrong and that the procedure is not a form of punishment
 - 5) Prepare with conversations about infusion procedures in advance
 - 6) Allow parent/caregiver(s) to remain during the procedure, if possible
 - 7) Provide a great deal of reassurance and clear explanations
5. School age
 - a. Social and emotional needs
 - 1) Major fears are bodily injury and mutilation, loss of control, not being able to live up to expectations of important others, and death
 - 2) Developing a sense of self-esteem and are interested in helping and pleasing
 - 3) Capable of following directions and can be involved in their treatment
 - 4) Becoming increasingly independent and may seek more privacy
 - b. Preparation for procedures
 - 1) Remember that this child can comprehend more detailed explanations
 - 2) Explain the procedure ahead of time using correct scientific/medical terminology, simple diagrams of anatomy and physiology, and demonstrating equipment
 - 3) Allow time before, during, and after the procedure for questions and discussion
 - 4) Remember this child can view himself separately from his parents and may prefer privacy (from parents and peers) during the procedures
 - 5) Encourage cooperation through praise and flattery
 - 6) Include in decision making, such as time of day to perform procedures or the preferred intravenous site
 - 7) If appropriate, discuss with child and parent/caregiver who will be present during the procedure for support
6. Adolescent
 - a. Social and emotional needs
 - 1) Increasingly capable of abstract thought and reasoning
 - 2) Very conscious of body image and appearance and fearful of something happening that will make him/her different from peers
 - 3) Taking more responsibility for decisions regarding personal healthcare needs
 - 4) May experience mood swings and regression in coping mechanisms
 - 5) While striving for independence, may have difficulty in accepting new authority figures and may resist complying with procedures
 - 6) May prefer solitary activities

- b. Preparation for procedures
 - 1) Prepare for procedure ahead of time
 - 2) Provide and guard privacy
 - 3) Include and encourage adolescent to participate in discussions regarding his/her condition and care
 - 4) Expect occasional noncompliance or lack of interest
 - 5) Answer questions honestly (do not talk down to patient) and explain the consequences of decisions or procedures



II. Patient Assessment

A. Patient History: Medical, Family, and Growth

- 1. Health perception/health management
 - a. Studies have reported that 60% of medical conditions in children can be diagnosed by history alone
 - b. Immunization status and exposure to communicable diseases
 - c. Medical history: the presence of chronic illnesses, congenital defects, hospitalizations, surgeries
 - d. Reason for seeking medical treatment
 - e. Onset and frequency of symptoms
 - f. Methods of treatment for current illness (include prescribed fluid mixtures and medications, over-the-counter drugs, and home remedies)
 - g. Information to obtain for children younger than 2 years (and when appropriate because of related developmental disabilities or complications of prematurity)
 - 1) Prenatal history: medications, complications, treatments
 - 2) History of labor and delivery, Apgar scores, complications
 - 3) Gestational age at delivery, birth weight, and length
 - 4) Congenital defects or neonatal illnesses
- 2. Nutritional metabolic pattern
 - a. Typical and current appetite
 - 1) Frequency of feedings
 - 2) Amount
 - b. Infant feeding patterns
 - 1) Method (e.g., breast, bottle, cup, feeding tube)
 - 2) Formula type
 - 3) Solid foods
 - 4) Fluids
 - c. Any difficulties perceived with diet or feeding behavior
 - 1) Choking or difficulty breathing with feeding; consider tracheoesophageal fistula
 - 2) Cyanosis with feeding; consider possible congenital heart defect
 - d. Vomiting in relationship to feedings
 - 1) Frequency
 - 2) Amount and characteristics of emesis
 - 3) Projectile (possibly indicative of pyloric stenosis or bowel obstruction)
 - 4) Timing of emesis in relation to feeding; assess for reflux
 - e. Food restrictions, allergies, or special diet intolerance
 - f. Other health problems or religious practices

- g. Vitamins or supplements
- h. Information for the child younger than 1 year: pattern of introduction of new foods
- 3. Medication history: dosages and frequency of medications taken in the last 2 months
- 4. Allergies
 - a. Food or medication
 - b. Potential allergic reactions associated with, but not limited to, intravenous medications, topical antimicrobial solutions or ointments, tape, and latex
 - c. Maternal allergies, especially for the newborn
- 5. Bowel elimination
 - a. Frequency, color, amount, odor, and consistency
 - b. Diarrhea (dehydration occurs rapidly in an infant experiencing diarrhea)
 - c. Toilet training and age when achieved
 - d. Presence of colostomy/ileostomy
 - e. Need for laxatives, enemas, or suppositories
- 6. Bladder elimination
 - a. Frequency, color, and odor of the urine
 - b. Problems associated with urination
 - 1) Bed-wetting
 - 2) Burning or other dysuria
 - 3) Dribbling
 - 4) Oliguria
 - 5) Polyuria
 - 6) Urinary retention
 - 7) Need for catheterization or presence of a stoma
 - c. Toilet training (during daytime or nighttime) and any accidents
 - d. If not toilet trained, the number and frequency of wet diapers in the last 24 hours (normally an infant will have at least six to seven wet diapers per day)
- 7. Skin integrity: complaints, abnormalities, chronic conditions, and presence of a rash
- 8. Activity-exercise pattern
 - a. Gross and fine motor skills
 - b. Self-care activity information appropriate to the child's age and developmental abilities
 - c. Normal affect
 - d. Effect of symptoms or complaints on activity patterns
- 9. Cognitive-perceptual pattern: any sensory perception deficits (hearing, smell, sight, touch)
- 10. Self-perception pattern: impact of illness on how the child feels about himself or herself
- 11. Role-relationship pattern
 - a. Questions appropriate for child's age and developmental abilities
 - b. Primary language spoken
 - c. Language development or characteristics of speech
 - d. Any concerns related to communication
- 12. Coping/stress management
 - a. Reactions to and coping methods for stress
 - b. Any losses or changes in the child's life in the past year
 - c. Support person

13. Family history
 - a. Significant medical histories of immediate family members to identify the genetic traits or diseases with familial tendencies
 - b. Diseases or conditions possibly influencing child's health
 - 1) Heart disease
 - 2) Diabetes
 - 3) Hypertension
 - 4) Cancer
 - 5) Obesity
 - 6) Congenital anomalies (e.g. heart defects)
 - 7) Growth or developmental abnormalities
 - 8) Allergies
 - 9) Asthma
 - 10) Coagulation disorders
 - 11) Sickle cell disease
 - 12) Convulsions
 - 13) Genetic conditions (e.g., cystic fibrosis)
 - 14) Mental or other emotional problems
 - 15) Syphilis
 - 16) Rheumatic fever
 - 17) History of maternal drug or alcohol abuse

B. Physical Examination

1. Growth measurements: record on chart for BSA calculations
 - a. Crown-to-heel recumbent length (children younger than 24 months)
 - b. Standing height/stature (children older than 24 months)
 - c. Weight (mass): record all measurements in grams/kilograms on growth chart
 - 1) Weigh unclothed infant on platform-type scale, measuring to the nearest 10 g or half ounce
 - a) Attempt to weigh each time under similar circumstances, such as before or after feedings, same time of day, same scale
 - b) Obtain a daily weight if the child is receiving infusion therapy or medications based on kilogram weight
 - 2) Weigh toddlers and older children on a standing scale, measuring to the nearest one-fourth pound; remove heavy clothing and shoes
 - 3) Compare prior weight to current weight as an indicator of fluid volume deficit (FVD) or excess
 - 4) Changes in weight should be monitored closely and reported to the licensed independent practitioner (LIP) if significant
 - 5) Assess for FVD by determining the percent of loss from normal BW
 - a) Percentage of weight loss equals level of dehydration
 - <5% loss = mild dehydration
 - 5% to 10% loss = moderate dehydration
 - > 10% loss = severe dehydration
 - b) Weigh an ill infant daily to determine the percentage of fluid loss
 - c) Weight loss caused by FVD occurs more rapidly than that caused by catabolism

2. Temperature
 - a. Assess baseline body temperature
 - b. Temperature measurement devices
 - 1) Mercury thermometers (mercury is a toxic substance) rarely used in clinical settings
 - 2) Electronic thermometer: axillary, oral, and rectal
 - 3) Tympanic membrane sensor is accurate only if probe fits well in ear canal (usually in children older than 1 year)
 - 4) Disposable strip
 - 5) Digital thermometer: axillary, oral, and rectal
 - 6) Temporal artery thermometer
 - c. Sites for measurement
 - 1) Rectal
 - a) Risk of rectal wall perforation; avoid with thrombocytopenia, neutropenia, or recent rectal surgery
 - b) Up to age 2 years
 - c) Normal range: 36.2°C to 37.8°C
 - 2) Axillary
 - a) Up to 4 to 6 years or older if condition indicates
 - b) Normal range: 36.5°C to 37°C
 - 3) Oral
 - a) Children older than 2 years who are cognitively able
 - b) Normal: 37°C
 - 4) Tympanic
 - a) May not be as accurate in children <3 years of age
 - b) Normal range: 35.8°C to 38°C
 - 5) Temporal
 - a) Normal ranges have not been established
 - b) Not recommended as a replacement for other devices as skin temperature may not be as reflective as a core temperature
 - d. Deviations from normal
 - 1) Subnormal temperature may be a sign of sepsis in the neonate and infant
 - 2) Elevated temperatures are seen in children early in dehydration, and as the condition worsens, the temperature may become subnormal
 - 3) Children younger than 3 years tend toward rapid temperature elevation and the resulting vulnerability to febrile seizures ($>39^{\circ}\text{C}/102^{\circ}\text{F}$)
 - 4) Each degree of rise or fall in temperature causes the basal metabolic rate (BMR) to increase
 - 5) Increase in BMR results in additional fluid and caloric requirements of 10% to 20% above maintenance requirements
3. Pulse
 - a. Assessment of rate and rhythm
 - 1) Apical pulse is the best site for auscultation; in children younger than 2 years, the apical pulse is more reliable than the peripheral pulse and should be assessed for rate and rhythm for 1 full minute
 - 2) In children older than 2 years, the radial pulse is satisfactory
 - b. Normal range
 - 1) Neonates/infants: 120 to 160 beats per minute (bpm)
 - 2) Toddlers: 90 to 140 bpm
 - 3) Preschoolers: 80 to 125 bpm

- 4) School age children: 70 to 100 bpm
- 5) Adolescents: 55 to 90 bpm
- c. Deviations from normal
 - 1) Changes in rate and rhythm may indicate changes in circulating blood volume or electrolyte imbalances
 - 2) Tachycardia may be an early sign of fluid depletion; as the condition worsens, the pulse becomes more rapid, weak, and thready
- d. Assessment of peripheral pulses
 - 1) Pulses palpable in adults are palpable in healthy children
 - 2) Evaluate presence and quality
 - a) During early childhood, a comparison between radial and femoral pulses should be done at least once to detect the presence of circulatory impairment, such as coarctation of the aorta (a congenital heart condition in which the lower extremity pressure is less than the upper extremity pressure)
 - b) Discrepancy between central and peripheral pulses may result from vasoconstriction
 - c) Pulse volume directly related to BP
 - d) Narrow pulse pressure, weak thready pulse may indicate shock
 - e) Widened pulse pressure, bounding pulse may indicate septic shock, fluid overload, or the presence of a patent ductus arteriosus
- 4. Respirations
 - a. Rate, rhythm, and depth should be noted in the same manner as for the adult
 - b. Normal range (rate/minute)
 - 1) Infants: 30 to 60
 - 2) Toddlers: 24 to 60
 - 3) Preschoolers: 20 to 30
 - 4) School age children: 16 to 22
 - 5) Adolescents: 15 to 20
 - c. Deviations from normal
 - 1) Apnea: defined as 15- to 20-second or longer period without respiration
 - 2) Alterations in rate may represent inadequate oxygenation or attempt to compensate for metabolic acid–base imbalances
- 5. BP
 - a. Assessment
 - 1) Use appropriate size cuff
 - 2) Child should be quiet and stabilized
 - 3) Measure in either upper arm or thigh in infants
 - 4) Measurements of the lower extremities should be done on any child with elevated pressures in the upper extremities and at least once during childhood to detect abnormalities such as coarctation of the aorta
 - 5) Not always a reliable sign of FVD in a young child because vessel elasticity may (initially) keep the BP stable, despite diminished blood volume
 - b. Normal range
 - 1) Infants
 - a) Systolic: 74 to 100 mmHg
 - b) Diastolic: 50 to 70 mmHg
 - 2) Toddlers
 - a) Systolic: 80 to 112 mmHg
 - b) Diastolic: 50 to 80 mmHg

- 3) Preschoolers
 - a) Systolic: 82 to 110 mmHg
 - b) Diastolic: 50 to 78 mmHg
- 4) School age children
 - a) Systolic: 84 to 120 mmHg
 - b) Diastolic: 54 to 80 mmHg
- 5) Adolescents
 - a) Systolic: 94 to 140 mmHg
 - b) Diastolic: 62 to 88 mmHg
- c. Deviations from normal
 - 1) May indicate a change in circulating blood volume
 - 2) FVD may decrease
 - 3) Fluid volume overload may increase
 - 4) In infants and children, may not be an accurate indicator of shock because the circulatory system may compensate
 - 5) Hypotension: sudden late onset is a sign of cardiac decompensation, which should be treated immediately because cardiopulmonary arrest may follow
6. Skin
 - a. Skin color
 - 1) Observed in natural daylight or neutral artificial light
 - 2) Color is the most reliably assessed in sclera, nail beds, ear lobes, lips, oral membranes, palms, and soles
 - 3) Factors affecting skin color include ethnic group (genetics), melanin production, edema, hygiene, hemoglobin level, and environmental temperature
 - a) Erythema (flushed or red skin) may result from increased environmental temperature, local inflammation, infection, or an increase in red blood cells (RBCs) as a compensatory response to chronic hypoxia (plethora)
 - b) Pallor, or paleness, may be a sign of anemia, chronic disease, hypothermia, edema, or shock
 - c) Jaundice is seen with an increase in bilirubin from hemolytic or liver disease
 - 4) Cyanosis
 - a) Central cyanosis, bluish discoloration of the skin
 - b) Occurs when there is <5 g/100 mL of desaturated hemoglobin in the circulating blood volume
 - c) May indicate hypoxia but is dependent on the hemoglobin concentration
 - 5) Acrocyanosis
 - a) Peripheral cyanosis, bluish discoloration of the extremities
 - b) Frequently seen in newborns because of reduced blood flow through small capillaries
 - c) Normal phenomena in newborns
 - d) Differentiation from central cyanosis is essential
 - b. Skin temperature
 - 1) Evaluated symmetrically by feeling each body part, comparing upper with lower extremities
 - 2) A child with FVD may feel cool to the touch even while febrile because of decreased peripheral blood flow

- c. Turgor
 - 1) Refers to the amount of elasticity in the skin, one of the best indicators of adequate hydration and nutrition
 - 2) Best determined by grasping skin on the abdomen (or medial aspect of the thigh) between thumb and index finger, pulling taut, and quickly releasing
 - 3) Normal tissue will not tent when gently lifted
 - a) Brief tenting (suspension) of the skin and wrinkling are generally seen after a 3% to 5% body fluid loss
 - b) An infant with hyponatremia will often have firm, thick-feeling skin
- d. Capillary refill; slow refill of more than 2 seconds indicates low cardiac output
- e. Edema
 - 1) Swelling or puffiness of the extremities or sacral area may be a sign of fluid excess or of several systemic disorders, such as heart failure, kidney disease, sepsis, or a protein deficiency
 - 2) Periorbital edema; may normally be present in children who have been crying, sleeping, or have allergies
- 7. Mucous membranes
 - a. Dry mouth may be caused by FVD or mouth breathing
 - b. Dryness along the area between the cheek and gum will be a more accurate measurement of fluid status
 - c. Salivation or drooling in an infant may be a significant source of fluid loss or indicative of adequate hydration; may also be a sign of tracheoesophageal fistula, esophageal atresia, or epiglottitis
 - d. The tongue of a child with FVD will appear smaller than the normal
 - e. Absence of tearing is seen with a fluid deficit of 5% or greater
- 8. Fontanel
 - a. Assessment
 - 1) Anterior fontanel is easily palpated in infants, generally closes by 24 months of age
 - 2) Assess when infant is quiet
 - 3) Assess for size, pulsation, and tenseness
 - b. Depressed or sunken fontanel is a sign of dehydration
 - c. Bulging fontanel when the infant is at rest may indicate increased intracranial pressure, hydrocephalus, or fluid overload
- 9. Urine
 - a. An adequate urine output for the newborn should be 0.5 to 1.0 mL/kg/hour and 1.0 to 2.0 mL/kg/hour for the infant
 - 1) Most accurate method of measuring output for a child not toilet trained is to weigh the diaper before putting it on and weigh it again after infant has voided
 - 2) One milliliter of urine will weigh 1 g
 - 3) Urine output should be measured hourly in dehydrated children
 - b. A urine specific gravity value between 1.002 and 1.030 is usually an indication of fluid balance
 - 1) High specific gravity occurs when there is protein or glucose in the urine or the urine is concentrated from FVD
 - 2) Because the renal system of infants and young children is immature, the specific gravity is a less reliable indicator of fluid status

10. Neurologic
 - a. Behavior
 - 1) Early signs of hypernatremia in infants and young children may include lethargy and somnolence
 - 2) Fluid retention and cerebral edema may cause restlessness and irritability
 - b. Changes in sensorium associated with fluid status may produce hypersensitivity to light and sound
 - c. Convulsions may be seen with fluid excess and fluid deficit

C. Laboratory Data

1. Serum electrolytes
 - a. Sodium
 - 1) Preterm neonate: 132 to 140 mmol/L
 - 2) Infant: 139 to 146 mmol/L
 - 3) Child: 138 to 149 mmol/L
 - 4) Adolescent: 136 to 146 mmol/L
 - b. Potassium
 - 1) Infant: 4.1 to 5.3 mmol/L
 - 2) Child: 3.4 to 4.7 mmol/L
 - 3) Adolescent: 3.5 to 5.1 mmol/L
 - c. Calcium
 - 1) Preterm neonate: <1 week of age: 6 to 10 mg/dL
 - 2) Infant: 7.5 to 11 mg/dL
 - 3) Child: 8.8 to 10.8 mg/dL
 - 4) Adolescent: 8.4 to 10.2 mg/dL
 - d. Chloride: 98 to 106 mmol/L
 - e. Magnesium
 - 1) Infant: 1.4 to 2.9 mEq/L
 - 2) Child: 1.6 to 2.6 mEq/L
 - f. Phosphorus/phosphate
 - 1) Preterm neonate: 4.6 to 8 mg/dL
 - 2) Infant: 5 to 7.8 mg/dL
 - 3) Children 28 days to 15 years: 3.2 to 6.3 mg/dL
 - 4) Children older than 15 years: equal to the adult value of 2.5 to 4.5 mg/dL
 - g. Bicarbonate
 - 1) Preterm neonate: 18 to 26 mEq/L
 - 2) Children younger than 2 years: 20 to 25 mEq/L
 - 3) Children older than 2 years: 22 to 26 mEq/L
2. Hemoglobin
 - a. Preterm infant: 13.4 to 15 g/dL
 - b. Infant: (0 to 2 weeks): 14.5 to 22.5 g/dL
 - c. Infant (2 weeks to 6 months): 9 to 14 g/dL
 - 1) Newborn hemoglobin level drops to its lowest point at approximately 3 to 6 months of age as a result of expansion of blood volume that accompanies rapid body growth
 - 2) Creates a condition referred to as physiologic anemia
 - d. Infant to child (6 months to 12 years): 11.5 to 15.5 g/dL
 - e. Adolescent (12 to 18 years, males): 13.0 to 16.0 g/dL
 - f. Adolescent (12 to 18 years, females): 12.0 to 16.0 g/dL

3. Hematocrit
 - a. Neonate: 44% to 75%
 - b. Infant: 28% to 42%
 - c. Children 6 months to 2 years old: 36%
 - d. Children 2 to 6 years old: 37%
 - e. Children 6 to 12 years old: 35% to 45%
 - f. Adolescents (equal to adult values)
 - 1) Males: 37% to 51%
 - 2) Females: 35% to 47%
 - g. Elevated hematocrit is seen with dehydration
4. Serum osmolality: equal to adult value of 280 to 300 mOsm/kg
5. Blood urea nitrogen (BUN)
 - a. Preterm neonate: 3 to 25 mg/dL
 - b. Neonate: 8 to 18 mg/dL
 - c. Infant or child: 5 to 18 mg/dL
 - d. Adolescent: 8 to 17 mg/dL
 - e. BUN possibly elevated in the presence of FVD
6. Serum glucose
 - a. Preterm neonate: 45 to 100 mg/dL
 - b. Neonate: 45 to 120 mg/dL
 - c. Children to 16 years: 60 to 105 mg/dL
 - d. Children older than 16 years: 70 to 115 mg/dL
7. Urine glucose
 - a. May be an early sign of sepsis
 - b. Children may have a low renal threshold for glucose and may experience glycosuria from high concentrations of glucose
8. Arterial blood gases (best method for assessing acid–base balance and quality of blood oxygenation)
 - a. pH: indicates the acid–base level of the blood
 - 1) Preterm neonate: 7.35 to 7.50
 - 2) Neonate: 7.27 to 7.47
 - 3) Infant and child: 7.35 to 7.45
 - b. PaO₂: values indicate how much oxygen the lungs are delivering to the blood
 - 1) 75 to 100 mmHg
 - c. PaCO₂: value indicates how efficiently the lungs eliminate carbon dioxide
 - 1) Infants: 27 to 40 mmHg
 - 2) All other ages: 35 to 45 mmHg
 - d. Base excess: +2 mEq/L
 - e. Oxygen saturation: 95% to 100%
9. Bilirubin: product of hemoglobin metabolism
 - a. Two forms
 - 1) Conjugated (direct)
 - a) Infant to adult: 0.1 to 0.4 mg/dL
 - 2) Unconjugated (indirect)
 - a) Infant to adult: 0.3 to 1.1 mg/dL
 - b. Hyperbilirubinemia
 - 1) During the first 3 days of life, 50% of neonates experience an elevation in plasma bilirubin, causing normal physiologic hyperbilirubinemia and resulting in jaundice
 - 2) Normal physiologic jaundice usually peaks during the first week, declining as the liver is increasingly able to conjugate and excrete bilirubin

- 3) In premature and breastfed neonates, increased blood levels of bilirubin can remain elevated for as long as 6 weeks
- 4) Excessive amounts of unconjugated (indirect) bilirubin may deposit in the brain, causing permanent damage to the central nervous system, a condition called kernicterus (an encephalopathy)
- 5) Treatment is phototherapy when serum bilirubin levels exceed 12 to 12.9 mg/dL
- 6) Increased insensible fluid loss occurs during phototherapy and may require a 25% increase in fluid intake
- 7) Bilirubin levels exceeding 20 mg/dL may be an indication for an exchange transfusion



III. Patient/Family Education

A. Education of Patient is Based on Developmental Level

B. When Possible, Include Parents during Sessions

C. Establish a Baseline of Knowledge

D. Allow Time for Questions, Consider Use of Play Therapy

E. Use Resource Materials if Available

F. Provide a Quiet Learning Environment

G. Discuss any Cultural, Religious, or Healthcare Beliefs that may affect the Learning Process

H. Document Teaching Sessions in Patient's Permanent Medical Record



IV. Infusion Therapy Supplies and Equipment

A. Administration Equipment

1. Infusion control devices: electronic infusion devices
 - a. Pump
 - 1) Accuracy of infusion rate/volume with ability to infuse in tenths of a milliliter for small doses or low rates
 - 2) Tamper-proof features; minimizing potential for child tampering
 - 3) Variable pressure limits and alarm features designed for pediatric patients
 - 4) Occlusion alarm ratings that fall within safety limits
 - 5) Syringe pump is a common volumetric pump frequently used in pediatrics for intermittent and continuous infusions
 - b. Mechanical controllers are not recommended for infants and children because accuracy cannot be guaranteed

2. Solution containers
 - a. Based on age and size of the child; should contain no more than 24-hour volume needs
 - b. Plastic, rather than glass, when possible to avoid the risk of breakage
3. Administration sets
 - a. Controlled volume set (50-, 100-, and 150-mL sizes) is indicated for all children whose infusion rate is <100 mL/hour, unless another volume control method, such as an electronic infusion device, is used
4. Special considerations
 - a. Consideration should be given to providing a latex-free environment
 - b. Reduce the risk of patient exposure to di-2-ethylhexyl phthalate (DEHP) by using polyvinyl chloride (PVC) devices (e.g., IV bags, administration sets, umbilical catheters) that do not contain DEHP; DEHP can leach out of medical devices into solutions, exposing the pediatric patient to potentially high harmful levels of DEHP

B. Vascular Access Devices (VADs)

1. Short peripheral catheters: similar to those for adults with the following exceptions:
 - a. Winged-steel needle sets should be avoided because they can become easily dislodged, potentially resulting in injury to the child
2. Midline catheters: similar to those for adults (see Chapter 1)
3. Central venous access devices: similar to those for adults
 - a. Periodic radiographic evaluation of catheter tip location is required due to infant/child growth during long-term therapy
 - b. Peripherally inserted central catheters: additional insertion sites are available in the scalp, jugular, and lower extremities veins
4. Intraosseous
 - a. Large-bore intraosseous needle is inserted into the medullary cavity of a long bone (1 inch away from the growth plate), which serves as a noncollapsible vein
 - b. Provides emergency access in children younger than 6 years when the access by the intravenous route is unobtainable
 - c. Preferred insertion sites are the distal or proximal tibia and distal femur
 - d. Intraosseous needles are for short-term use only and should not be left in place longer than 24 hours
 - e. The intraosseous needle should be removed once adequate vascular access has been established
5. Umbilical catheters
 - a. 2.5, 3.5, and 5.0 French flexible rigid-walled radiopaque umbilical catheter, single or multiple lumen inserted into an umbilical artery or vein
 - b. Provides vascular access, BP, and blood gas monitoring in critically ill neonates
 - c. May be used for exchange transfusions
 - d. Placement is considered a medical act that may be performed by a LIP competent in the technique
 - e. Umbilical venous catheter (UVC)
 - 1) Proper line placement is the junction of the inferior vena cava and right atrium
 - 2) Catheter size is determined by weight and clinical status

- 3) May be used for administration of medications and solutions with caution; if tip position is not correct, medications/solutions may be delivered directly into the liver, potentially resulting in necrosis
- 4) Should be removed as soon as no longer needed but can be used as long as 14 days if managed aseptically
- 5) Complications include hemorrhage, infection, air embolism, malposition, portal vein thrombosis, and arrhythmias
- f. Umbilical arterial catheter (UAC)
 - 1) Two umbilical arteries are available
 - 2) High line placement in descending aorta with the tip above the diaphragm at T₇ and T₁₀ is preferred
 - 3) Use for medication administration is with extreme caution because drugs are introduced directly into some of the major arteries (e.g. renal artery)
 - a) Drugs that cause vasoconstriction, are chemically irritating, or are extremely hyperosmolar are not recommended for UAC administration
 - b) Because of the potential risks, the UAC should be the last choice for intravenous medications and parenteral solutions
 - 4) Optimally should not be left in place longer than 5 days
 - 5) Complications include hemorrhage, thrombosis, infection, ischemia, and arrhythmias
- g. Care and maintenance
 - 1) The length of insertion is determined by using a standardized graph or regression formula
 - 2) Cleanse the umbilical insertion site with an antiseptic before catheter insertion; avoid tincture of iodine because of the potential effect on the thyroid; other iodine-containing products (e.g., povidone iodine) can be used
 - 3) Tip placement should be verified before any medications or solutions are infused
 - 4) Once placement is verified, catheters should be secured with suture and a tape bridge
 - 5) Do not use topical antibiotic ointment or cream on umbilical catheter site because of the potential to promote fungal infections and antimicrobial resistance
 - 6) Umbilical catheters should be removed and not replaced if any signs of catheter-related bloodstream infection, vascular insufficiency, or thrombosis are present
 - 7) Frequent inspection of lower extremities and buttocks for blanching and cyanosis, which may indicate vascular insufficiency and thrombosis
 - 8) Monitor umbilical site for bleeding, migration of the catheter from designated insertion length, and infection
 - 9) Monitor respiratory status, peripheral pulses, and check for edema, which may indicate emboli formation
 - 10) Monitor quality of blood return from catheter and observe wave form on monitor; dampening and sluggish blood return may indicate thrombosis
6. Special considerations
 - a. VAD selection should be a multidisciplinary process involving the health-care team, family members, or caregivers, and the child, if developmentally appropriate
 - b. In addition to physical assessment, an assessment of the child's activity level, developmental stage, and environment are essential considerations in providing safe and effective infusion therapy

- c The anatomic location of blood vessels in children is relatively the same as in adults, although access can be challenging because of the vessel size and activity of the patient; infants and young children have the advantage of additional sites in the scalp and lower extremities
- d. When selecting sites and devices for the neonate (both term and preterm); the blood vessels are small, immature, prone to rupture, and fragile, limiting access; consideration should be given to using a midline or peripherally inserted central catheter in the following circumstances:
 - 1) When duration of therapy is likely to exceed 6 days
 - 2) Inability to tolerate feedings
 - 3) Gastrointestinal disorder
 - 4) Congenital heart disease
 - 5) Limb anomalies



V. Venipuncture

A. Site Selection

1. Peripheral: upper extremity; similar to that of the adult, with the following special considerations:
 - a. Hand: dorsal venous network
 - 1) Possible difficult insertion secondary to subcutaneous tissue in infants
 - 2) Digital veins: useful if unable to access other sites; however, infiltrates easily; extremely small in infants; difficult to stabilize
 - b. Forearm: may be difficult to visualize and access because of subcutaneous tissue in infants and toddlers
 - c. Antecubital fossa: accessory cephalic; may not be easily palpated on children; difficult to secure catheter; elbow joint must be maintained in extended position
 - d. Upper arm (below axilla)
 - 1) Basilic: largest vein in upper arm with straightest pathway to thoracic vessels
 - 2) Cephalic: smaller than basilic; pathway in upper arm and thorax may be tortuous
 - 3) Brachial: two veins adjacent to basilic and in close proximity to brachial artery and median nerve; imaging guidance necessary to access this vein
2. Peripheral: lower extremity; used before crawling and walking age; large vessels usually easy to palpate
 - a. Greater saphenous: located close to bifurcating veins connecting to deep veins of the leg
 - b. Lesser (small) saphenous
 - c. Metatarsal (foot)
 - 1) Do not use in patients who are crawling or walking
 - 2) Dorsal venous network
 - a) May not be easily palpated secondary to age or disease-related changes
 - b) Complications related to impaired circulation, difficulty stabilizing joint
 - 3) Medial and lateral margins of foot
 - a) May be large
 - b) Usually easy to palpate and visualize
 - 4) Popliteal
 - a) In neonate, usually easy to palpate and visualize

3. Scalp veins: use before 18 months
 - a. Disadvantages
 - 1) Cannot be used for chemotherapy or other vesicants
 - 2) Stabilization is often difficult, requiring the removal of hair if present
 - 3) Infiltrates easily
 - 4) Increases family anxiety; prepare ahead of time if possible
 - b. Advantages
 - 1) Veins dilate readily
 - 2) Highly visible and possess no valves, reducing the risk of trauma to the vessel on insertion
 - c. Available sites
 - 1) Superficial temporal: located at front of the ear
 - 2) Occipital
 - 3) Frontal: located in middle of forehead
 - 4) Posterior auricular
4. Umbilical
 - a. Three vessels in umbilical cord: two arteries and one vein
 - b. Umbilical arteries: thick-walled, small-diameter lumen
 - c. Umbilical vein: thin-walled, with large-diameter lumen, easier to catheterize
 - d. Generally accessible to 4 days of life
5. Central: tip location in lower one-third of the superior vena cava, cavoatrial junction, or inferior vena cava
 - a. Jugular (two internal and two external)
 - 1) External jugular is more commonly accessed in infants
 - 2) Access may be difficult because of short, thick neck
 - 3) Increased complications secondary to patient activity and difficulty stabilizing catheter
 - b. Additional insertion sites are available for peripherally inserted central catheters in neonates, infants, and small children
 - 1) Lower extremities
 - a) Catheter tip termination in inferior vena cava
 - b) Greater and lesser saphenous veins
 - c) Femoral veins
 - d) Popliteal veins
 - 2) Sites where catheter tip terminates in the distal one-third of the superior vena cava or cavoatrial junction
 - a) Axillary veins
 - b) Superficial temporal veins
 - c) External jugular veins
 - d) Posterior auricular veins
6. Intraosseous (see Chapter 1)

B. Procedural Pain Management

1. Assessment
 - a. Pain is assessed and reassessed at regular intervals before, during, and after procedures
 - b. Consider developmental age
 - c. Physiologic and behavioral cues are objective and valid indicators of pain
 - d. Common physiologic responses to pain include changes in heart rate and decreased oxygen saturation
 - e. Common behavioral cues regarding pain are facial grimacing, crying, and body movements

- f. Inability to communicate does not negate the possibility that the pediatric patient is experiencing pain
 - g. Situations usually considered to cause pain in adults should be assumed to cause pain in the pediatric patient, even in the absence of behavioral or physiologic signs
 - h. Valid and reliable multidimensional instruments should be used to assess the pain
 - i. Medications and interventions should be tailored specifically to the type of procedure, the child, and the anticipated length of pain after the procedure
2. Pain management techniques
- a. Nonpharmacological: based on developmental level
 - 1) Neonate and infant: swaddling, non-nutritive sucking (sucrose water), modification of environment, including dimming of lights, minimizing noise, soft music
 - 2) Toddler: verbal reassurance, parents to provide supportive care, calm soothing voice
 - 3) Preschooler: diversional activity and parental support
 - 4) School age child: distraction and parental support per child
 - b. Pharmacologic
 - 1) Requires a LIP order
 - 2) Opioids: reserved for moderate, severe, or prolonged pain
 - 3) Local anesthetics
 - a) When local anesthesia is ordered or required, the agent that is least invasive or carries the least risk will be considered first
 - b) Routinely used for PICC and CVC insertion, contraindicated in patients with known allergy or sensitivity to local anesthetics
 - c) Types
 - Lidocaine hydrochloride
 - Buffered lidocaine: 2% lidocaine buffered with sodium bicarbonate
 - EMLA (eutectic mixture of lidocaine-prilocaine anesthetic): may be considered before peripheral VAD insertion or port access; must be applied 60 minutes before performing the procedure; indicated for infants older than 36 weeks gestational age
 - ELA Max (lidocaine 4%)—topical anesthetic cream
 - Needle-free pressurized delivery system—rapid delivery of lidocaine hydrochloride

C. Insertion Techniques

- 1. Method of venipuncture the same for children as for adults, but certain techniques enhance successful venipuncture
- 2. Always have extra personnel to lend assistance during venipuncture procedure; consider the use of child life specialist for preparation and support during the procedure
- 3. Use methods to maintain thermal stability during procedures, including heat lamps, isolettes, radiant warmers, hats, and coverings
- 4. Use heat or visualization technologies for vein identification as needed
- 5. Use a rubber band or small latex-free tourniquet
- 6. Maintain skin integrity; this is especially important with neonates
 - a. Use adhesives such as tape sparingly
 - b. Remove tape gently to avoid epidermal stripping

- c. Avoid the use of solvents and bonding agents
 - d. Remove preparation agents with sterile water or saline once the procedure is complete to avoid absorption
 - e. Limit the use of tincture of iodine because it may affect thyroid function
 - f. Avoid the use of alcohol, which is drying to the skin and has been associated with chemical burns in the preterm neonate
7. VAD stabilization is essential, particularly in the younger child whose level of comprehension concerning the importance of not manipulating the insertion site is minimal
 8. Fully explain venipuncture procedures to parents and child if appropriate; this is especially important if considering a scalp vein for inserting a peripheral IV or PICC; offer the clipped hair as a keepsake
 9. During scalp vein insertion, aim the catheter downward, toward the heart
 10. Secure extremities in normal joint position, using a padded IV board if necessary
 11. Perform intravenous procedures in a treatment room when the child is developmentally aware of his/her surroundings, thus preserving the child's room and bed as a "safe haven" where invasive procedures are not performed

D. Care and Maintenance

1. Frequent assessment and monitoring (include physical condition, infusion site, and equipment) for potential complications
2. Infusion rate must be monitored closely to avoid fluid volume overload; the margin for error is small
3. Growth subsequent to CVC insertion may necessitate periodic radiographic evaluation of tip location
4. Insertion site must be readily visible; roller bandages should never be around the insertion site
5. Peripheral venous catheters can be left in place until IV therapy is completed if the site is free of complications (e.g., phlebitis, infiltration)
6. Site assessments include condition of the site and surrounding area, document assessment in the patient's permanent medical record
7. Catheter-site dressing regimens: at least every 7 days for transparent dressings, except for pediatric patients in whom the risk for dislodging the catheter outweighs the benefit of changing the dressing. Change gauze and tape dressings every 48 hours
8. Additional securement of the VAD should be considered as a safety measure such as an expandable netting over extremity to secure tubing and dressing
9. Never use scissors to remove vascular and nonvascular access device dressings, tape, or stabilization devices



VI. Pharmacology

A. Medication Administration: Special Considerations

1. Pharmacokinetics, drug efficacy, and adverse effects are dynamic in neonates/infants because of growth and organ maturity
2. Lack of knowledge regarding developmental pharmacology may result in therapeutic toxicities as a result of two types of toxicity:
 - a. Toxicity caused by immaturity of the metabolism or elimination processes
 - b. Toxicity caused by percutaneous absorption

3. Consideration must be given to the effects of age on pharmacokinetics and pharmacodynamics
 - a. Absorption (gastric, intramuscular, and percutaneous) varies with age
 - b. Volume of distribution: percentage of body water and BSA influence the distribution of drugs
 - c. Protein binding: neonates have decreased binding capacity compared with adults
 - d. Metabolism: neonates metabolize drugs at a slower rate than do adults
 - e. Elimination: renal function matures with age
4. Fluctuations in BW are common in the pediatric patient and may affect drug distribution
 - a. A 10% to 20% change in BW may indicate a need to recalculate drug doses
 - b. Advisable to use birth weight (rather than actual daily weight) for all drug and fluid calculations for the first week of life until fluid equilibrium is attained
 - c. An estimated dry weight should be used for calculations for seriously ill, very edematous infants and children
5. Calculations for pediatric medication administration are commonly based on BW (kilograms) and BSA (by the use of a nomogram)
 - a. Dosing is usually recommended in terms of BW: milligrams (mg) or micrograms (mcg) per kilogram (kg)
 - b. BSA meters squared (m^2): most common method used to calculate pediatric chemotherapy
 - c. Clinicians should be knowledgeable about calculations for drugs dosed in mcg/kg/minute and mg/kg/minute
 - d. Doses for neonates and infants are commonly calculated to the tenths of a milligram or milligram
 - e. Concentrations of medications are often manufactured for administration to adults and may be too high to permit accurate measurement for tiny doses; dilution is suggested to ensure accuracy:
 - 1) Dose volumes of <0.1 mL, prepare a 1:10 dilution
 - 2) Dose volumes of <0.01 mL, prepare a 1:100 dilution
 - 3) A two-syringe dilution technique should be used to accommodate the dead space in the syringe and avoid an inadvertent overdose
6. Administer only those medications approved for pediatric use
7. For children younger than 2 years, use preservative-free medications

B. Methods of Pediatric Medication Administration

1. Intravenous push/bolus method: medication administered directly into the vein (usually during a 1- to 5-minute period)
2. Metered volume chamber (buret) method
 - a. Drug is injected into and infused with a compatible maintenance solution in the buret
 - b. Commonly used in pediatric settings
 - c. Not generally recommended in neonates/infants because the infusion rates are too slow
 - d. Drug must be compatible with primary solution
3. Syringe pump method
 - a. A 1- to 60-mL syringe containing the medication is attached to low-volume tubing; the tubing is primed, connected to the port most proximal to the patient, and the medication is infused at the prescribed rate
 - b. Preferred method with neonates and infants

- c. Preferred and most accurate method offering the most control over drug administration and decreasing the potential for underdosing or overdosing
- d. Suggested for
 - 1) Drugs given by continuous infusion
 - 2) Drugs given in volumes >5 mL
 - 3) Drugs given over a prescribed period of time
- 4. Retrograde method
 - a. Less commonly used in the newborn intensive care unit; specific retrograde tubing, generally <1 mL, with stopcocks on each end is attached to the primary administration set and primed
 - b. To administer medications
 - 1) Attach the medication-filled syringe to the port most proximal to the patient
 - 2) Attach an empty syringe to the distal port
 - 3) Clamp the tubing between the patient and the proximal port
 - 4) Inject the medication distally up the tubing (away from the patient) displacing the fluid into the empty syringe
 - 5) Remove both syringes, unclamp tubing, and allow medication to infuse at the rate of the primary infusion
 - c. Method often used in infants to reduce the risk of fluid overload because extra fluid is not given with each medication dose



VII. Disease States and Conditions

A. Fluid Volume Imbalances

- 1. General goals
 - a. To support vital functions, maintain health, and encourage adequate growth, the body must be supplied with water, electrolytes, nutrients, and vitamins (maintenance requirements)
 - 1) Pediatric patients are more vulnerable to fluid volume imbalance due to proportionately more ECF to body size, larger BSA, increased metabolic rate, immature kidneys, and less homeostatic buffering capability
 - b. To replace deficits of fluid or electrolytes lost via insensible fluid losses (skin, respiratory tract, perspiration, gastrointestinal tract, and urine)
 - 1) FVD is expressed in percentage of fluid and weight loss
 - a. Mild: $<5\%$
 - b. Moderate: 5% to 10%
 - c. Severe: 10% to 15%
 - 2) Acute loss of 15% of BW will likely cause hypovolemic shock, a common problem in children in need of emergency care
 - 3) FVD is categorized according to sodium levels
- 2. Maintenance requirements
 - a. Calculate maintenance fluid requirements for a 24-hour period
 - b. Based on child's weight in kilograms (mL/kg) using the following steps:
 - 1) Calculate the weight of the child in kilograms (kg) (2.2 lb/kg)
 - 2) 100 mL/kg for first 10 kg (1 to 10 kg of BW)
 - 3) 50 mL/kg for next 10 kg (11 to 20 kg of BW)
 - 4) 20 mL/kg for each kg over 20
 - 5) Divide the total amount by 24 hours to obtain the infusion rate in milliliters per hour (mL/hour)

- c. Based on the BSA or milliliters per meters squared
 - 1) Recommended for children with more than 10 kg of BW
 - 2) Plot weight and height on nomogram to determine the BSA
 - 3) Maintenance requirements based on BSA; water: 1,200 to 1,500 mL/m² per 24-hour period
- d. Based on metabolic rate
 - 1) 100 mL water needed for every 100 calories consumed
 - 2) Caloric expenditure related to weight as follows:
 - a) 2 to 10 kg: 10 calories per kg
 - b) 10 to 20 kg: 50 calories for each kg over 10
 - c) >20 kg: 20 calories per kg
- e. Variables increasing fluid requirements
 - 1) Premature neonates may require 60 to 140 mL/kg/day, depending on gestational age, clinical status, and assessment data
 - 2) Elevated temperature: a 1° elevation in temperature increases fluid requirements by 12%
 - 3) Stress
 - 4) Burns
 - 5) Surgery
- 3. Replacement therapy
 - a. Phase I: initial management
 - 1) Replacement of vascular volume is essential
 - 2) Requires immediate treatment and rapid fluid management
 - 3) Infusion of crystalloid solution: 20 mL/kg should be infused during a 20-minute period
 - 4) Dextrose solutions should be omitted to prevent hyperglycemia
 - 5) Lactated Ringer's solution is preferred
 - 6) Type of solution for initial volume expansion is a matter of controversy
 - 7) Additional boluses may be administered based on the assessment of response to therapy
 - a) Hypovolemic shock often requires 40 to 60 mL/kg during the first hour
 - b) Septic shock: 60 to 80 mL/kg during the first hour
 - b. Phase II: repletion and maintenance therapy
 - 1) 2 to 24 hours after onset of deficit
 - 2) Replacement is combined with maintenance
 - 3) Acid–base and electrolyte disturbances are partially corrected
 - 4) Amount of fluid infused in Phase I should be subtracted, and ongoing losses should be added to calculations
 - c. Phase III: early recovery
 - 1) May last 24 to 96 hours
 - 2) Goal is to correct remaining deficits in hypertonic dehydration
 - 3) Electrolyte imbalances should be corrected slowly so as not to impair neurologic status
 - 4) Oral rehydration should be instituted if condition permits
- 4. FVD: isotonic dehydration
 - a. Water and electrolytes are lost proportionately from ICF and ECF compartments
 - b. Etiologic factors: most common form of dehydration
 - 1) Loss of large quantities of liquid stools
 - a) Gastroenteritis is the most common cause
 - b) Approximately 70% of children with FVD caused by severe diarrhea experience isotonic dehydration

- 2) Fever
- 3) Excessive emesis, gastrointestinal suctioning, and fistula drainage
- 4) Hemorrhage
- 5) Burns: fluid and electrolytes shifting within the circulatory system may lead to shock
- 6) Decreased fluid intake
- 7) Polyuria
- c. Clinical manifestations
 - 1) Thirst
 - 2) Acute weight loss
 - 3) Dry skin and mucous membranes, poor skin turgor, gray or ashen skin, and cold extremities as a result of poor peripheral perfusion
 - 4) Subnormal temperature (unless infection is present)
 - 5) Lethargy
 - 6) Oliguria with increased specific gravity
 - 7) Sunken eyeballs as a result of decreased intraocular pressure
 - 8) Diminished tearing: seen with fluid loss greater than 5% total BW
 - 9) Weak, rapid pulse
 - 10) Depressed fontanel in neonates and infants
 - 11) Longitudinal furrows on the tongue
 - 12) Signs of hypovolemia
 - 13) Serum sodium at normal levels
- d. Treatment
 - 1) Follow guidelines for replacement therapy
 - 2) Mild isotonic dehydration may be treated with oral rehydration
 - 3) Frequent monitoring of vital signs, accurate intake and output, and daily weights
5. FVD: hypertonic (hypernatremic) dehydration
 - a. Resulting from a greater loss of water than electrolytes; net loss of water in excess of salt or a result of excessive solute intake
 - b. Etiologic factors
 - 1) Diarrhea: approximately 20% of children lose more water than electrolytes
 - 2) Neonates and infants fed high-solute replacement fluids or a concentrated formula (too little water mixed with the formula)
 - 3) Fever with hyperventilation (especially in small infants)
 - 4) Diabetes type 1: insulin dependent
 - a) Disorder of the immune system; beta cells in pancreas are destroyed resulting in deficiency in insulin; difficulty in maintaining blood glucose levels
 - b) Copious amounts of fluid and few electrolytes lost (through polyuria, for example)
 - 5) Diabetes type 2: noninsulin-dependent
 - a) Excess glucose concentration in blood, with effects similar to those of excess sodium concentration (hyperosmolar dehydration), causing water movement out of cells into the ECF
 - b) Osmotic diuresis causes excessive fluid loss and possible elevated serum sodium
 - 6) History of low water intake
 - c. Clinical manifestations
 - 1) History of large quantities of liquid stools
 - 2) Extreme thirst (hypertonic ECF drawing water from cells and causing dehydration)

- 3) Serum electrolytes
 - a) Elevated BUN
 - b) Potassium levels within low normal range
 - c) Sodium levels exceeding 145 mEq/L
 - d) Elevated chloride levels
- 4) Altered central nervous system
 - a) Marked lethargy and extreme hyperirritability with stimulation
 - b) Potential for seizures, coma, and tremors secondary to hypernatremia, causing brain tissue to shrink
 - c) Intracranial bleeding may occur in 10% of infants and young children
- 5) Muscle rigidity
- 6) Nuchal rigidity (pain or stiffness in back or neck)
- 7) Oliguria
- 8) Loose skin turgor; cold, thick, firm-feeling skin
- 9) Weight loss
- 10) Increased urine specific gravity
- d. Treatment
 - 1) Gradual replacement of water losses with a dilute sodium solution (5% dextrose and 0.225% sodium chloride with potassium chloride) during a 48-hour period
 - 2) Too rapid rehydration can lead to brain swelling, resulting in seizures and coma
 - 3) Potassium chloride is not given until adequate renal function is verified
6. FVD: hypotonic (hyponatremic) dehydration
 - a. Greater loss of electrolytes than of water
 - b. Etiologic factors
 - 1) Diarrheal episodes, especially when treated with electrolyte-free solutions for volume replacement
 - 2) Syndrome of inappropriate antidiuretic hormone (SIADH)
 - a) Excessive release of ADH or similar substance
 - b) Excessive ADH leads to decreased water excretion
 - c) Results in decrease in serum sodium level and osmolality
 - d) Increased fluid volume with resultant increased glomerular filtration and decreased aldosterone release
 - e) Subsequent increased sodium elimination
 - f) Because intracellular concentration is greater, ECF is pulled into the cells
 - g) Predisposing factors: medications, including nonsteroidal anti-inflammatory drugs; tumors, especially oat cell carcinoma; and central nervous system disorders
 - 3) Diuretic therapy
 - 4) Excessive amounts of salt-poor solutions
 - 5) Neonates and infants fed a formula too diluted with water
 - 6) Fresh-water drowning
 - c. Clinical manifestations
 - 1) Serum electrolytes
 - a) Elevated BUN
 - b) Potassium levels within high normal range
 - c) Sodium levels <130 mEq/L
 - 2) Neuromuscular symptoms caused by cerebral edema
 - a) Lethargy
 - b) Seizures
 - c) Coma

- 3) Dry, sticky mucous membranes
- 4) Weight loss
- 5) Subnormal temperature
- 6) Poor skin turgor; cold, clammy, and dusky skin
- 7) Extremities cool to the touch
- 8) Hypotension
- 9) Rapid, thready pulse
- 10) Hypovolemic shock (in severe cases) is caused by cardiovascular dysfunction and inadequate tissue perfusion (volume depletion)
- d. Treatment
 - 1) Dependent on the severity of fluid and electrolyte loss
 - 2) Sodium, the major electrolyte in ECF; accompanying deficit is the primary cause of symptoms
 - a) If sodium level is low and neurologic changes are present, hypertonic sodium solutions (5% dextrose in 0.45% sodium chloride) may be necessary
 - b) Avoid rapid administration to prevent shrinkage of brain tissue
 - c) Hypertonic solution promotes return of fluid from the extracellular space into the intracellular space
7. Fluid volume excess (FVE)
 - a. Result of abnormal retention of water and sodium; hypervolemia
 - b. Etiologic factors
 - 1) Fluid overload; administered too rapidly or in excess volume
 - 2) Dysfunction or immaturity of the homeostatic mechanisms for regulating fluid balance
 - a) Congestive heart failure
 - b) Renal failure
 - c) Excess steroids
 - d) Cirrhosis
 - 3) Excessive sodium ingestion
 - c. Clinical manifestations
 - 1) Peripheral edema (excess interstitial space fluid)
 - 2) Distended neck or peripheral veins
 - 3) Decreased BUN and hematocrit (result of plasma dilution)
 - 4) Decreased heart rate with full, bounding pulse (infant may experience tachycardia as a result of difficulty managing the increased intravascular volume)
 - 5) Pulmonary edema (if severe)
 - 6) Moist crackles on auscultation of lungs
 - 7) Decreased urine specific gravity (urine dilute)
 - 8) Hypertension
 - 9) Polyuria (if normal renal function)
 - 10) Weight gain
 - 11) Hepatomegaly (seen in chronic fluid overload in children)
 - d. Treatment
 - 1) Sodium and water intake restrictions
 - 2) Dialysis (if renal function is compromised)
 - 3) Diuretics
 - e. Prevention
 - 1) Use electronic flow control device
 - 2) Limit the amount of fluid hung

B. Hemolytic Diseases of the Newborn

1. Rh incompatibility
 - a. Etiologic factors
 - 1) Rh-negative mother produces anti-Rh antibodies toward fetal red cells, which possess Rh-positive antigens
 - 2) Maternal antibodies of the immunoglobulin G (IgG) class cross the placenta, resulting in a hemolytic fetal process
 - b. Clinical manifestations
 - 1) Hyperbilirubinemia and jaundice of the neonate within the first 24 hours of life
 - 2) Anemia secondary to hemolysis
 - 3) Erythroblastosis fetalis (immature RBCs [erythroblasts] in fetal circulation)
 - 4) Hydrops fetalis
 - a) Most severe form of erythroblastosis fetalis
 - b) Progressive hemolysis, causing fetal hypoxia, cardiac failure, anasarca (generalized edema)
 - c) In utero, fetal transfusion may be considered if condition warrants
 - d) Pericardial, pleural, and peritoneal space effusions and respiratory distress
 - c. Treatment
 - 1) Maternal RhoGAM (RhIG): intramuscular administration within 72 hours of each delivery to mother as protection for subsequent deliveries
 - 2) Phototherapy: intensive therapy should result in a decrease in total serum bilirubin (TSB) level by 1 to 2 mg/dL within 4 to 6 hours; TSB should continue to fall and remain below threshold for exchange; therapy is considered failure if this does not occur
 - 3) Exchange transfusion to correct anemia, lower serum bilirubin levels, and remove sensitized erythrocytes; indicated by the following:
 - a) Positive result of direct Coombs' test
 - b) Cord blood hemoglobin <12 g/dL
 - c) Bilirubin level 20 mg/dL or greater in the full-term neonate
 - d) Bilirubin levels increasing >1 mg/dL/hour despite phototherapy
 - e) Bilirubin levels >15 to 16 mg/dL in the preterm infant
 - f) Failure of phototherapy
2. ABO incompatibility
 - a. Etiologic factors
 - 1) Most common blood group incompatibility in the neonate is between maternal O blood group and infant A or B blood group
 - 2) Maternal anti-A or anti-B antibodies from the maternal circulation cross the placenta and cause hemolysis of fetal RBCs
 - b. Clinical manifestations
 - 1) Jaundice during the first 24 hours: hemolyzed agglutinated donor cells are trapped in peripheral blood vessels
 - 2) Serum levels of unconjugated bilirubin rise rapidly after birth; 15 to 20 mg/dL or an increase of 1 mg/dL or more per hour
 - 3) Anemia from erythrocyte hemolysis; if severe, pallor and hypovolemic shock can occur
 - 4) Hepatosplenomegaly

c. Treatment

- 1) Indications for phototherapy and exchange transfusion are the same as with Rh incompatibility
- 2) Generally not severe enough for exchange transfusion; resolves with phototherapy or a single transfusion of red cells

C. Pyloric Stenosis

1. Hypertrophy of the circular muscle of the pylorus, leading to an obstruction of the gastric outlet and causing gastric distention and vomiting
2. Etiologic factors
 - a. Causative mechanisms leading to hypertrophy are unclear
 - b. Genetics appears to play a significant role
 - c. Most common cause of vomiting in neonates 2 to 4 weeks of age and is seen five times more often in males than in females
 - d. Complications of progressive pyloric obstruction may include dehydration, weight loss, malnutrition, and electrolyte disturbances
3. Clinical manifestations
 - a. Early: neonate is alert and ravenously hungry but appears mildly dehydrated and malnourished
 - b. Progressive
 - 1) Palpable pyloric mass: commonly referred to as an olive
 - 2) Peristaltic waves (left to right toward pylorus) possibly seen after feedings but before vomiting
 - 3) Projectile vomiting: prolonged and frequent emesis causing fluid and electrolyte imbalances
 - 4) Metabolic alkalosis: pH above 7.45
 - 5) Potassium deficit: level below 3.5 mEq/dL
 - 6) FVD is hypotonic (hyponatremia)
 - 7) Fretful, apathetic
 - 8) Loss of skin turgor
 - 9) Dry mucous membranes
4. Treatment
 - a. Nothing by mouth (NPO)
 - b. Intravenous fluids to correct fluid and electrolyte imbalances
 - c. Glucose correction
 - d. If the child is severely dehydrated, correction may take 24 to 48 hours
 - e. Pyloromyotomy
 - 1) Treatment of choice after correction of fluid, glucose, and electrolyte abnormalities
 - 2) Surgical procedure to relieve the obstruction caused by the hypertrophied muscle

D. Hypoglycemia

1. Abnormally low level of serum blood glucose
2. Etiologic factors
 - a. Inadequate intake of glucose (dextrose)
 - b. Overproduction of insulin from islets of Langerhans or an overdose of exogenous insulin
 - c. Abrupt discontinuation of intravenous dextrose solutions
 - d. High glucose demand and low glucose stores; most commonly occurs in infants with acute illness

3. Clinical manifestations
 - a. Blood glucose of <40 to 45 mg/dL
 - b. Jitteriness, tremors, twitching
 - c. Lethargy
 - d. Apathy
 - e. Poor feeding or sucking ability; refusal to feed; infant with low glucose may lack the energy to take oral fluids
 - f. Hypotonia: decreased strength, limpness
 - g. Irritability
 - h. Headache
 - i. Mental confusion
 - j. Hallucinations
 - k. Weak or high-pitched cry
 - l. Prolonged or severe hypoglycemia (glucose below 40 mg/dL), leading to convulsions or seizures
 - m. Increased epinephrine secretion causes tachycardia, BP elevation, sweating, and anxiety
 - n. Hypothermia, especially in neonates and infants
 - o. Rapid and irregular respirations or apnea, usually self-limiting, may develop in infants
 - p. Diaphoresis, cyanosis, pallor, congestive heart failure, and eye-rolling
4. Treatment
 - a. Oral glucose, especially within the first hours of birth and every 2 to 3 hours thereafter; formula or breast milk feedings are preferred to sucrose
 - b. Intravenous dextrose
 - 1) Most common is 10% solution, but may range to 50% solution
 - 2) Usually an intravenous bolus followed by a continuous infusion
 - 3) Monitor bedside glucose levels closely
 - 4) Required to maintain physiologic requirements of blood serum glucose concentrations
 - 5) Infusion administered through large peripheral vein or central vein to increase hemodilution and prevent extravasation
 - 6) High concentrations of dextrose, such as parenteral nutrition (PN), must be terminated gradually
 - 7) Minimize interruption of infusion of dextrose solutions
 - a) Restart peripheral catheter in a timely manner, especially in neonates or infants
 - b) Evaluate impact of dextrose solution interruption
 - c) If necessary, start a second intravenous site to enable dextrose solution and medications or a blood transfusion to infuse concurrently
 - d) Maintain infant in a neutral thermal environment, minimize stress

E. Gastroenteritis

1. Etiologic factors
 - a. Viruses (rotaviruses, enteric adenovirus), bacteria, parasites, or other toxins
 - b. Pathogens infect or damage the cells of the intestinal wall; small intestine most common
 - c. Occurs most frequently between the ages of 3 months to 2 years of age
2. Clinical manifestations
 - a. Frequent diarrhea
 - b. Anorexia, nausea, and vomiting; may result in fluid and electrolyte losses; may lead to dehydration

- c. Fever may be present
 - d. Tachycardia
 - e. Weight loss
3. Treatment
- a. Rehydration with oral solutions or IV fluids
 - b. Administration of antiemetics
 - c. Administration of antibiotics for specific pathogens (e.g., *E. coli*, *Salmonella*)
 - d. Advance diet as tolerated

F. Salicylate Intoxication (Salicylism)

1. Etiologic factors
- a. Toxic serum levels of salicylate; sources such as aspirin, methyl salicylate, sustained-release preparations, enteric-coated formulations, and liniments
 - b. Maternal ingestion of toxic quantities
 - c. Excessive topical application of methyl salicylate (oil of wintergreen)
 - d. Therapeutic misuse of salicylates: administered too frequently, incorrect dose, ingestion of topical agent
2. Clinical manifestations
- a. Gastrointestinal: nausea, vomiting, gastric irritation; large doses of salicylates lead to decreased gastric motility
 - b. Metabolic: hyperthermia, hypoglycemia (more common in children), and hypokalemia; disturbance in acid–base balance results in respiratory alkalosis and metabolic acidosis, either alone or combined
 - c. Respiratory: hyperpnea, hyperventilation, and pulmonary edema
 - d. Dehydration: secondary to hyperventilation
 - e. Neurologic: tinnitus, confusion, coma, and seizures
 - f. Renal: oliguria
 - g. Hepatic: hepatitis and altered liver function tests
 - h. Hematologic: hypoprothrombinemia and hemorrhagic (clotting) disorders
 - i. Diaphoresis
 - j. Serum salicylate level >150 mg/kg
3. Treatment
- a. Prevent further salicylate absorption by gastric lavage or induced emesis (through the administration of activated charcoal or syrup of ipecac) or saline cathartic
 - b. Administer antidote (*N*-acetylcysteine [NAC, Mucomyst]) for acetaminophen
 - c. Establish adequate circulatory blood volume by administering an isotonic solution at a rate of 20 mL/kg/hour; lactated Ringer's solution and sodium bicarbonate may be required in children to correct metabolic acidosis and urinary alkalization and enhance elimination
 - d. Administer a minimum of 25 mEq/L potassium to correct electrolyte deficits and to alkalize the urine; maintaining urine pH above 7.50 enhances salicylate excretion
 - e. Administer dextrose (5 g/dL) when renal function is adequate to treat ketosis
 - f. Administer calcium gluconate to treat tetany
 - g. Give vitamin K (Aquamephyton) to prevent excessive bleeding
 - h. Give osmotic diuretics to increase urine output (monitor for FVD)
 - i. Monitor blood volume status, sodium, potassium, bicarbonate, urine pH, and arterial blood gases to determine appropriate intravenous fluid type, medications, and rate of administration
 - j. Anticipate hemodialysis for severe intoxication

G. Cystic Fibrosis

1. Overview
 - a. Hereditary condition marked by accumulation of viscous mucous and abnormal secretion of sweat and saliva; affected individuals exhibit pancreatic deficiency and pulmonary disease
 - b. Pancreas and bronchioles become obstructed as secretions thicken in ducts or glands
 - c. Bacteria may stick to the mucous and increase the risk of infection
 - d. Most common lethal genetic disease among white children, adolescents, and adults because of its numerous multiorgan system complications
2. Etiologic factors
 - a. An inherited autosomal recessive trait
 - b. Affects 1 in every 3,700 infants born in the United States
3. Clinical manifestations
 - a. Sweat abnormality
 - 1) Sodium and chloride concentrations >60 mEq/L required for diagnosis
 - 2) Failure to reabsorb sodium and chloride increases potential risk for abnormal salt loss, dehydration, hyponatremic and hyponatremic alkalosis, especially with high environmental temperatures or febrile episodes
 - 3) Infants are especially at risk because of limited fluid stores and the potential for limited salt intake with commercially prepared formulas
 - b. Pulmonary
 - 1) Progressive chronic obstructive pulmonary disease
 - 2) Most respiratory symptoms will develop by age of 3 years
 - 3) Wheezing respirations, dyspnea
 - 4) Dry, nonproductive cough initially, may progress to loose, productive cough
 - 5) Bronchial and bronchiolar obstruction promote secondary infection and recurrent pneumonia
 - 6) Barrel-shaped chest secondary to disease progression
 - 7) Cyanosis and clubbing of fingers and toes caused by impaired gas exchange
 - 8) Chronic sinusitis and nasal polyps
 - 9) Chronic hypoxia leads to pulmonary hypertension, respiratory failure, and eventual cor pulmonale
 - 10) Fatigue
 - c. Gastrointestinal
 - 1) Meconium ileus: in 15% to 20% of newborns with cystic fibrosis, thick meconium blocks the small intestine, causing intestinal obstruction
 - 2) Pain, abdominal distention, and vomiting throughout life as a result of thick intestinal secretions
 - 3) Obstruction of pancreatic enzymes leads to large, frothy, foul-smelling stools (steatorrhea)
 - 4) Weight loss or failure to thrive despite healthy appetite and diet, thin extremities
 - 5) Fat soluble vitamin deficiency leads to bruising
 - 6) Anemia
 - 7) Rectal prolapse: most common gastrointestinal complication; result of large, bulky stools and lack of supportive fat pads around rectum in infants and young children

4. Treatment
 - a. Aerosolized drugs to administer normal saline, mucolytics, bronchodilators, and antibiotics
 - b. Chest physiotherapy: postural drainage and percussion of the lungs to facilitate mucous expectoration
 - c. Prophylactic oral antibiotics at the time of diagnosis
 - d. Intravenous antibiotic therapy during acute episodes after sputum culture and sensitivity; the most common infections include *Pseudomonas aeruginosa*, *Pseudomonas cepacia*, and *Staphylococcus aureus*
 - e. Oral replacement of pancreatic enzymes
 - f. High-protein, high-caloric diet, water-miscible forms of vitamins
 - g. Enteral alimentation, if history of inability to gain weight
 - h. Electrolyte replacement therapy, especially during hot weather or physical exertion
 - i. Lung transplantation: usually performed in children with advanced pulmonary vascular disease and hypoxia
 - j. Replacement gene therapy

H. Meningitis

1. Overview
 - a. Acute inflammation of the meninges
 - b. Children <5 years of age are the most frequently affected, peak incidence 6 to 12 months of age
2. Etiologic factors
 - a. The most common route of infection is indirectly from other sites in the body; children with an underlying immune deficiency
 - b. By direct implantation from penetrating wounds (e.g., skull fracture or lumbar puncture)
 - c. Bacterial or pyogenic: most commonly caused by *Streptococcus pneumoniae*, or *Neisseria meningitidis*, but also by other bacterium
 - d. Aseptic (nonbacterial or viral): wide variety of causative viral agents (e.g., enteroviruses)
 - e. Children with a cochlear implant are high risk
 - f. Consider pneumococcal vaccine for high-risk populations
3. Clinical manifestations (depends on the age of the child)
 - a. Full-term infant
 - 1) Low-grade fever or subnormal temperature
 - 2) Pallor
 - 3) Change in behavior: lethargy, irritability, high pitch cry or difficult to console
 - 4) Poor feeding or sucking, vomiting, diarrhea
 - 5) Decreased muscle tone, episthotonic posturing, or seizure disorder
 - 6) Bulging fontanelles
 - b. Infant/young child
 - 1) Alteration in sensorium: lethargy, agitation, high pitch cry, irritability, or difficult to console; photophobia
 - 2) Pallor
 - 3) Anorexia, poor feeding, nausea, and vomiting
 - 4) Increase in intracranial pressure, increase in head circumference, bulging fontanelles, seizures, or "sunset eyes"

- c. Older child
 - 1) Headache, irritability, photophobia, spinal, or nuchal rigidity
 - 2) Fever
 - 3) Vomiting
 - 4) Positive Kernig's sign
 - 5) Positive Brudzinski's sign
 - 6) Opisthotonic posturing
 - 7) Petechia, usually with meningococemia
 - 8) Shock, disseminated intravascular coagulation (DIC)
- d. Lumbar puncture is positive for causative organism; protein concentration is usually increased
- e. Elevated white blood count (WBC) count
- f. Blood cultures occasionally are positive when cerebrospinal fluid culture is negative
- 4. Treatment
 - a. Primarily symptomatic for nonbacterial meningitis
 - b. Medical emergency for bacterial meningitis
 - c. Respiratory isolation for at least 24 hours
 - d. Acetaminophen for headache or muscle pain; steroids as an adjunct to decrease inflammation
 - e. Maintenance of optimum hydration involving correction of fluid deficits followed by low maintenance levels to prevent cerebral edema
 - f. Environmental stimuli kept to a minimum (decrease noise, bright lights, and other external stimuli)
 - g. Intravenous antibiotics: based on the causative organism identified
 - h. Reduction of increased intracranial pressure
 - i. Intravenous infusion started as soon as possible to administer antibiotics, electrolytes, anticonvulsive therapy (for seizures), and manage hypovolemic shock, as well as heparin for DIC
 - j. Control of extremes of temperature
 - k. Correction of anemia (blood administration)

I. Blood Disorders

- 1. Sickle Cell Anemia
 - a. Etiologic factors
 - 1) Normal adult hemoglobin (hemoglobin A [HbA]) is partly or completely replaced by abnormal sickle hemoglobin (HbS)
 - 2) Inherited as an autosomal recessive gene and found primarily in African-Americans
 - 3) Under conditions of dehydration, infection, hypoxia, and temperature elevations, HbS distorts to a crescent or sickle-shape RBC
 - 4) The sickle-shape RBC has a decreased capacity to carry oxygen and an increased rate of destruction as compared with normal RBCs
 - 5) As long as fetal hemoglobin persists, sickling does not occur
 - 6) During the first year of life, fetal hemoglobin decreases, placing the child at risk for sickle cell-related complications. Newborn screening for sickle cell and early intervention can decrease morbidity and mortality

b. Clinical manifestations

- 1) Vaso-occlusive crisis (painful crisis) related to ischemia in tissue distal to obstruction caused by the sickled RBC
 - a) Most children with sickle cell will experience this type of crisis by age 6
 - b) Exercise, high altitudes, dehydration, or infection can be precipitating factors
 - c) Symptoms
 - Irritability
 - Vomiting, decreased appetite
 - Fever
 - Pain, swelling in the extremities, decreased range of motion
 - Cerebrovascular accident
- 2) Sequestration crisis, majority of cases occur before age 2
 - a) Crisis due to enlarged spleen, initially caused by engorgement of sickle cells
 - b) Spleen can rupture or atrophy
 - c) Symptoms
 - Nausea and vomiting, abdominal pain
 - Respiratory and circulatory collapse, shock
- 3) Aplastic crisis: transient suppression of RBCs
 - a) May be precipitated by an infection
 - b) Usually occurs in children <10 years of age
 - c) Symptoms
 - Weakness
 - Fatigue
 - Decreased appetite
 - Pallor
 - Fever
 - Dyspnea
 - Tachycardia and shock
- 4) Functional asplenia: functioning spleen cells are replaced by fibrotic tissue by age 5 years; without the spleen filtering bacteria and promoting release of phagocytic cells, the child is at risk for infection
- 5) Anemia and capillary obstruction cause liver failure and necrosis, with cirrhosis eventually occurring
- 6) Kidney ischemia (secondary to glomerular congestion) results in hematuria, inability to concentrate urine, enuresis, and occasionally, nephrotic syndrome
- 7) Chronic ischemia of the bone results in osteoporosis, osteomyelitis, and occasionally, aseptic necrosis of the femoral head
- 8) Stroke or cerebrovascular accident is a major complication
 - a) Serial transcranial Doppler ultrasonography for children at high risk for a stroke
 - b) Other neurologic symptoms include headache, aphasia, weakness, convulsions
 - c) Visual disturbances or paralysis, possibly resulting from cerebral thrombosis caused by increased viscosity of blood
- 9) Cardiomyopathy, decompensation, and cardiac failure
- 10) Exercise intolerance, anorexia, jaundiced sclera, and gallstones
- 11) Vaso-occlusion and tissue ischemia, causing chronic leg ulcers in adolescents
- 12) Delayed physical growth (height and weight)

- 13) Delayed sexual maturation and decreased fertility
- 14) Depression, low self-esteem
- 15) Recurrent attacks of fever, and pain in the arms, legs, and abdomen, possibly beginning in early childhood
- c. Treatment
 - 1) Avoid contact sports; damage to spleen will cause massive internal hemorrhage
 - 2) Desferal infusion intravenously or subcutaneously to chelate iron stores caused by routine blood transfusions
 - 3) Bed rest to decrease cellular metabolism; minimize energy expenditure and oxygen use
 - 4) Hydration for hemodilution (oral or intravenous)
 - 5) Electrolyte replacement to correct metabolic acidosis caused by hypoxia
 - 6) Analgesics for pain
 - 7) Blood transfusions to treat anemia and reduce viscosity of sickled blood
 - 8) Antibiotics for infections as appropriate
 - 9) Oxygen therapy in severe crisis: continuous administration of oxygen can depress bone marrow activity, causing anemia to worsen
 - 10) Bone marrow transplantation
2. Hemophilia
 - a. Overview
 - 1) Hemophilia is an inherited, congenital blood dyscrasia characterized by the absence or malfunction of one of the factors necessary for blood coagulation, resulting in impaired coagulability and a tendency to bleed
 - 2) Factor VIII deficiency (hemophilia A or classic hemophilia) accounts for 75% of all cases
 - 3) Hemophilia B is a factor IX (plasma-thromboplastin component) deficiency
 - 4) Hemophilia C is a factor XI deficiency (plasma-thromboplastin antecedent)
 - b. Etiologic factors
 - 1) Transmitted as an X-linked recessive disorder
 - 2) As many as one third of cases may be caused by gene mutation
 - 3) Commonly appears in males; is transmitted by females
 - c. Clinical manifestations: clinical severity varies depending on the plasma level of the coagulation factor involved
 - 1) Mild (patients with factor levels of 25% to 50% of normal): bleeding from severe trauma or surgery, spontaneous bleeding does not occur
 - 2) Moderate (patients with factor levels above 5% but less than 25% of normal): bleeding occurs from moderate trauma
 - 3) Severe (patients with factor levels <1% of normal): may have spontaneous bleeding or bleeding from minor trauma into the subcutaneous tissue, muscles, or joints (hemarthrosis)
 - d. Treatment
 - 1) Immobilization and elevation of affected area
 - 2) Local pressure to affected area to allow for clot formation
 - 3) Administration of factor VIII or IX; primary prophylaxis
 - a) Method of choice for treating young children
 - b) Treatment is 2 to 3 times a week to prevent bleeding episodes, thereby preventing muscle and joint damage

- c) Intensive therapy that requires placement of a vascular access devices, such as an implantable port
- d) Family is taught to infuse clotting factor at home
- 5) Current therapies
 - a) Recombinant factors VIII and IX
 - b) Most factor VIII products still stabilized with human albumin, but the goal is to eventually rid concentrates of any human products
 - c) Drug therapies
 - Desmopressin: stimulates release of factor VIII
 - Amicar: antifibrinolytic to stabilize clots

J. Necrotizing Enterocolitis (NEC)

1. An acute inflammatory disease of the bowel
2. Risk factors include ischemic bowel injury, bacterial colonization, and presence of enteral feedings
3. Etiologic factors
 - a. Appear to occur in neonates whose gastrointestinal tracts have experienced vascular compromise and stop producing protective lubricating mucous, allowing the intestinal walls to be attacked by proteolytic enzymes
 - b. Intestinal ischemia of unknown etiology
 - c. Enteric feedings of hypertonic substances (e.g., formula and hyperosmolar medications)
 - d. Gastrointestinal bacterial proliferation
 - e. Presence of UVCs
4. Clinical manifestations: onset usually between 3 and 12 days of life or with initiation of feedings, but can occur within the first 24 hours of life
 - a. NEC (stage 1)
 - 1) Mild abdominal distention
 - 2) Guaiac positive stools
 - 3) Lethargy
 - 4) Poor feeding, increase in gastric residuals
 - 5) Decrease in peripheral perfusion
 - 6) Apnea and bradycardia
 - 7) Emesis (often bile-stained)
 - 8) Temperature instability
 - b. NEC (stage 2) includes some of the symptoms above and the following:
 - 1) Grossly bloody stools
 - 2) Abdominal tenderness
 - 3) Palpable bowel loops
 - 4) Edema of abdominal wall
 - 5) Bowel sounds may be absent
 - c. NEC (stage 3) acutely ill infant with peritonitis and/or radiographic confirmation of intestinal perforation
 - 1) Septic shock
 - 2) Evidence of abdominal wall erythema and edema
 - 3) Right lower quadrant abdominal mass
 - 4) Metabolic and/or respiratory acidosis
 - 5) DIC
5. Laboratory findings
 - a. Anemia
 - b. Leukopenia

- c. Elevated WBC with an increase in band count
- d. Metabolic and/or respiratory acidosis
- e. Electrolyte imbalances
- f. In severe cases, DIC or thrombocytopenia
- g. Positive cultures of blood, stool, or urine
- 6. Treatment
 - a. Bowel rest, NPO
 - b. Abdominal decompression via nasogastric suction
 - c. Intravenous antibiotic administration
 - d. Correction of extravascular volume depletion, electrolyte abnormalities, acid-base imbalances, and hypoxia
 - e. Obtain serial abdominal radiographs to monitor for the presence of pneumatosis or bowel perforation
 - f. Provide ventilatory support as needed
 - g. Surgical correction of intestinal perforation (resection and anastomosis or creation of an ostomy)

K. Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS)

- 1. Etiologic factors
 - a. HIV type I is the causative agent for AIDS
 - b. Transmission of the virus occurs by sexual contact, parenteral exposure to blood (direct blood-to-blood contact with an individual infected with HIV), or from an HIV-infected mother to child (in utero or via breastfeeding)
 - c. Immunosuppression is a result of a decreased number of CD4 T cells
 - d. Abnormal B-cell function is apparent early in pediatric HIV infection
- 2. Clinical manifestations
 - a. Most children with perinatally acquired AIDS appear healthy at birth but experience symptoms within the first 6 months of life
 - b. Lymphadenopathy
 - c. Recurrent upper respiratory tract infections
 - d. Secondary cancers: Kaposi's sarcoma is found in <1% of affected children
 - e. Confirmed HIV in blood or tissues
 - f. CD4 T-lymphocyte counts are <200 cells/microliter
 - g. Hepatosplenomegaly
 - h. Thrombocytopenia
 - i. Recurrent pulmonary diseases, including *Pneumocystis carinii* pneumonia, lymphocytic interstitial pneumonitis, pulmonary lymphoid hyperplasia, and tuberculosis
 - j. Failure to thrive (infants with HIV)
 - k. Chronic diarrhea (either primary from HIV or secondary from opportunistic gastrointestinal infections)
 - l. Neurologic involvement occurs in 75% to 90% of children with HIV
 - 1) Developmental delay or loss of motor skills
 - 2) Decreased brain growth (microencephaly or abnormal neurologic examination results)
 - m. Chronic candidiasis
- 3. Treatment
 - a. Directed at slowing the progression of the virus; prevention, management, and treatment of opportunistic infections and nutritional support; there is no cure

- b. Intravenous gamma globulin administration for B-lymphocyte deficiency
- c. Therapy for *Pneumocystis carinii* pneumonia
 - 1) Trimethoprim/sulfamethoxazole (Bactrim, Septra)
 - 2) Pentamidine isethionate
 - 3) Intravenous pentamidine, if side effects or sensitivities occur secondary to the Bactrim
- d. Nutritional support: enteral or PN

L. Cancer

- 1. Leukemia
 - a. Overview
 - 1) Cancer of the hematopoietic tissues that are responsible for producing WBCs
 - 2) In children, the two forms generally recognized are acute lymphocytic leukemia (ALL) and acute myelocytic leukemia (AML)
 - 3) The clinical course of the acute (immature cells) leukemias is similar for all types
 - b. Etiologic factors: etiology is unknown, although several factors are associated with increased incidence
 - 1) 75% to 80% of childhood leukemia is ALL
 - 2) Familial predisposition and genetic influence (e.g., increased risk with Down syndrome)
 - c. Clinical manifestations
 - 1) ALL
 - a) Anemia with fatigue, generalized malaise, and pallor
 - b) Fever or infection (secondary to granulocytopenia, neutropenia)
 - c) Pain in joints and bones (from rapidly expanding marrow in the bone)
 - d) Swelling of lymph nodes, spleen, and liver
 - e) Hemorrhage or petechiae from thrombocytopenia (decreased platelet count)
 - f) Anorexia and weight loss
 - g) Vague abdominal pain (intestinal tract inflammation)
 - h) Headache, neck pain
 - 2) AML
 - a) In addition to the symptoms of ALL
 - b) Hypertrophy of the gingiva
 - c) Leukemia cutis: bluish, nontender skin nodules called chloromas (tumors of AML blasts)
 - d. Treatment
 - 1) Central venous access device insertion to facilitate vascular access for chemotherapy, multiple blood sampling or transfusion, and antibiotic administration
 - 2) High-dose chemotherapy
 - 3) Bone marrow transplantation
 - 4) Total body irradiation
 - 5) Analgesics and narcotics to relieve pain
 - 6) Adequate nutrition (enteral or parenteral)
- 2. Wilms' tumor
 - a. Overview
 - 1) Usually large encapsulated tumor arising from the renoblast cells in the renal parenchyma

- 2) Separated from kidney by a membranous capsule
- 3) Originates from renoblast cells located in kidney's parenchyma
- 4) Larger tumors may extend across the midline and to surrounding structures, causing obstruction of the inferior vena cava or intestines
- 5) Associated with congenital anomalies in 10% of the patients
- 6) Tumor grows rapidly; tissue type varies to "favorable" and "unfavorable" pathologic conditions
- 7) Metastasis occurs through bloodstream to lungs and liver
- 8) Tumor may spread through lymphatics to the retroperitoneal lymph nodes
- 9) Do not palpate the tumor, which may result in seeding of the tumor elsewhere or can cause pulmonary embolization
- b. Etiologic factors
 - 1) Accounts for 6% of childhood cancers
 - 2) Peak incidence is 2 to 3 years of age
 - 3) Prognosis varies according to stage of disease and cell histologic findings
 - 4) Overall survival rate with favorable histologic findings and nonmetastatic disease is 90%
- c. Clinical manifestations (first three symptoms are predominant)
 - 1) Flank mass
 - 2) Pain
 - 3) Hematuria
 - 4) Hypertension
 - 5) Fever
 - 6) Malaise
 - 7) Weight loss
- d. Treatment
 - 1) Surgery (nephrectomy or removal of affected kidney)
 - 2) National Wilms' Tumor Study Group staging system: five stages reflect extent of disease, treatment is based on stage of disease
 - 3) Postoperative radiation therapy or chemotherapy is initiated
3. Neuroblastoma
 - a. Overview
 - 1) Soft, solid tumors that originate from neural crest cells
 - 2) Precursors of the adrenal medulla and sympathetic nervous system
 - 3) May be present wherever sympathetic nervous tissue is found
 - 4) Common primary tumor sites are the abdomen, adrenal gland, or paraspinal ganglia
 - 5) Generally encapsulated, often impinge on adjacent tissues and organs
 - b. Etiologic factors
 - 1) Etiology unknown
 - 2) Most common extracranial solid tumor of childhood and most common neoplasm of infants
 - 3) Unique phenomenon of spontaneous tumor regression and maturation into benign forms allow many to go undetected
 - 4) Prognosis is favorable if diagnosis is made before 12 months of age and if disease is in early stages
 - c. Clinical manifestations (symptoms related to location of tumor)
 - 1) Palpable mass that is firm and irregular
 - 2) Altered bowel or bladder function

- 3) Vascular compression with edema of the lower extremities
- 4) Pain and weakness of lower extremities
- 5) Sensory loss
- 6) Loss of sphincter control
- 7) Symptoms related to neck and thoracic mass vary
- d. Treatment
 - 1) The International Staging System for Neuroblastoma standardizes definitions for diagnosis, staging, and treatment
 - 2) Children with favorable prognostic features generally require no treatment, minimal treatment, or surgical resection alone
 - 3) Treatment based on staging ranges from surgical resection only to intensive therapy, including chemotherapy, radiation, surgery, bone marrow transplant, and immunotherapy

M. Biliary Atresia

1. Overview
 - a. Complete obstruction of bile flow caused by fibrosis of the extrahepatic ducts
 - b. Most common form of ductal cholestasis; incidence is 1 in 10,000 births; there is a female predominance
 - c. Obstruction prevents bile from entering duodenum
 - d. Digestion and fat absorption are impaired, leading to deficiencies in fat soluble vitamins and vitamin K, which impact bleeding tendencies
 - e. Bile accumulates in ducts and gallbladder, progressing to the intrahepatic ducts, leading to biliary cirrhosis and ultimately death if bile flow is not established
 - f. Survival with untreated disease is <2 years
2. Etiologic factors
 - a. Etiology is unknown
 - b. Multiple theories
 - 1) Obstruction caused by injury to bile ducts, leading to atresia
 - 2) Inflammatory process
 - 3) Intrauterine insult from environmental factors or failure of ducts to recannulize
3. Clinical manifestations
 - a. Appear normal at birth, with the appearance of subtle clinical signs
 - b. Persistent jaundice after the first week
 - c. Slow increase in direct bilirubin, resulting in greenish bronze appearance of skin
 - d. Stools gradually change color from clay to pale to yellowish-tan
 - e. Urine becomes dark as a result of bile excretion
 - f. During a period of 2 to 3 months, the liver becomes cirrhotic, and portal hypertension develops with resulting complications
 - g. Bleeding and anemia may result from alterations in clotting ability
4. Treatment
 - a. Surgical intervention involves a hepatic portoenterostomy—dissection and resection of the extrahepatic bile duct
 - b. Success rates for surgical intervention range from 45% to 85% with satisfactory bile drainage

- c. Prognosis is best when surgery is done before 2 months of age
- d. When surgical intervention fails, liver transplant is an alternative therapy
- e. Nutritional requirements
 - 1) Needs one and one-half to two times the normal caloric requirements because of metabolism
 - 2) Ascites and pressure on the stomach make it difficult to eat
 - 3) Enteral or PN may be needed to provide adequate caloric requirements

BIBLIOGRAPHY

- Betz, C. L., & Snowden, L. A. (Eds.). (2008). *Mosby's pediatric nursing reference* (6th ed.). St. Louis, MO: Mosby/Elsevier.
- Fernandes, A., et al. (2011). Procedural pain management for neonates using nonpharmacological strategies: Part 1: Sensorial interventions. *Advances in Neonatal Care*, 11(4), 235–241. doi: 10.1097/ANC.0b013e318225a2c2
- Frey, A. M., & Pettit, J. (2010). Intravenous therapy in children. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 550–570). St. Louis, MO: Saunders/Elsevier.
- Infusion Nurses Society. (2011). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S1–S110.
- Kumar, R., Pruthi, R. K., & Rodriguez, V. (2009). Central venous access devices (CVAD) for pediatric patients with hemophilia, a review. *Journal of Coagulation Disorders*, 1(1), 85–91.
- Nash, P. (2006). Umbilical catheters, placement, and complication management. *Journal of Infusion Nursing*, 29(6), 346–352.
- O'Grady, N. P., Alexander, M., Burns, L. A., Dellinger, E. P., Garland, J., Heard, S.O., ... Healthcare Infection Control Practices Advisory Committee. (2011). Guidelines for the prevention of intravascular catheter-related infections. *American Journal of Infection Control*, 39(4 Supplement 1): S1–S34. doi: 10.1016/j.ajic.2011.01.003.
- Pagana, K. D., & Pagana, T. J. (2012). *Mosby's diagnostic and laboratory test reference* (11th ed.). St. Louis, MO: Mosby.
- Pettit, J., & Mason Wycoff, M. (2007). *Peripherally inserted central catheters: Guideline for practice* (2nd ed.). Glenview, IL: The National Association of Neonatal Nurses.
- Uman, L., Chambers, C. T., McGrath, P. J., Kisely, S., Matthews, D., & Hayton, K. (2010). Assessing the quality of randomized controlled trials examining psychological interventions for pediatric procedural pain: Recommendations for quality improvement. *Journal of Pediatric Psychology*, 35(7), 693–703. doi: 10.1093/jpepsy/jsp104

Transfusion Therapy

Deb Richardson, MS, RN, CNS



I. Immunohematology

A. Definition: study of the immune system and immune response as it specifically relates to the antigens and antibodies found in the blood

1. Antigens
 - a. Also referred to as agglutinogens
 - b. Found on the surface of the red cell
 - c. Are inherited
 - d. Are glycoproteins or glycolipids
 - e. Can invoke an immune system response
2. Antibodies
 - a. Also referred to as agglutinins
 - b. Proteins found in plasma
 - c. React to specific antigens found on red cells
 - d. May occur naturally (inherited) or may result from immunization (acquired)
 - e. Can cause agglutination in presence of red cells that exhibit the corresponding antigen

B. ABO System

1. Group A: contains antigen A on the red cell and antibody B in the plasma and thus may receive red cells from groups A and O
2. Group B: contains antigen B on the red cells and antibody A in the plasma and thus may receive red cells from groups B and O
3. Group AB: contains both antigens A and B on the red cells and does not have any corresponding antibodies
 - a. As a result, group AB may receive red cells from blood groups A, B, AB, and O
 - b. Group AB is considered a universal recipient for red cells

Table 6–1 Blood Group Antigens: ABO Systems

ABO Group	Antigen	Antibody
A	A	B
B	B	A
AB	A and B	Neither A nor B
O	Neither A nor B	A and B

4. Group O: contains no antigens on the red cells but has both antibodies A and B in the plasma
 - a. Must receive red cells from group O
 - b. In emergency situations, group O may be administered to any other blood group until ABO blood grouping has been established (see Table 6-1)

C. Rh System

1. Rh factor: approximately 50 known Rh antigens
2. Antigen D is the factor to be considered in transfusion therapy
 - a. Rh positive: antigen D is found on the red cell
 - b. Rh negative: no antigen D is found on the red cell
 - c. Rh-negative blood can be administered to Rh-positive types
 - d. Rh-positive blood produces antibodies when administered to Rh-negative types
 - e. Rh compatibility is extremely important in women of childbearing age to reduce the potential for complications during pregnancy

D. Human Leukocyte Antigen (HLA)

1. Essential to immunity
2. Component of histocompatibility system, which controls compatibility between transfusion recipients and donors
3. Predominately found on leukocyte cell family: neutrophils, basophils, and eosinophils
4. Protein in immune system that has a role in self-recognition of the immune system
5. Plays a role in several transfusion therapy complications
 - a. Immune-mediated platelet refractoriness
 - b. Febrile nonhemolytic (FNH) reaction
 - c. Transfusion-associated graft-versus-host disease (TA-GVHD)
 - d. Transfusion-related acute lung injury (TRALI)



II. Types of Transfusions

- A. Random donor—blood obtained and stored in the blood bank for transfusion to an unknown recipient
- B. Direct donor—a person donates blood for transfusion to a specific individual (many times a family member)

C. Autologous—(Autotransfusion)

1. Collection and reinfusion of patients own blood for the purpose of volume replacement
2. Four categories of autotransfusion
 - a. Preoperative autologous blood transfusion
 - 1) Collected before surgery, with the last unit drawn no <72 hours before surgery
 - 2) Provides red cell alloimmunization
 - 3) Provides compatible blood for those with alloantibodies
 - 4) Must be transfused within 4 hours of hanging
 - b. Perioperative isovolemic hemodilution
 - 1) Collected in OR usually after induction of anesthesia
 - 2) Patient must be able to tolerate rapid blood withdrawal and significant blood loss
 - 3) Up to 2 L of blood are collected immediately before surgery
 - 4) Blood is then replaced with adequate volume of crystalloid or colloid solution to achieve normovolemic hemodilution
 - 5) Blood can be stored at room temperature in OR but should be transfused within 8 hours
 - 6) If surgical procedure is expected to last >8 hours, blood should be refrigerated but must be transfused within 24 hours
 - 7) This process may not prevent or eliminate the need for homologous blood use
 - c. Intraoperative autotransfusion
 - 1) Cost-effective only if three units of blood can be reinfused
 - 2) Contraindicated when gross bacterial contamination or seeding of malignant cells is a possibility
 - 3) Must be labeled with the patient's name, hospital identification number, date and time collection begun, and time of expiration; label should indicate "For Autologous Use Only"
 - 4) Must be reinfused within 8 hours
 - 5) Amount collected and reinfused should be documented in the operative procedure note
 - d. Postoperative blood salvage
 - 1) Collection may begin in the operating room at time of closure
 - 2) Must be reinfused within 6 hours of collection using aseptic technique
 - 3) Must be labeled with the patient's name, hospital identification number, date and time collection begun, and time of expiration; label should indicate "For Autologous Use Only"
 - 4) Transfusion guidelines and organizational policies and procedures for transfusion therapy must be followed



III. Blood and Blood Components

A. Whole Blood

1. Composition: contains red cells, white cells, platelets, and plasma
2. Volume: approximately 450 to 500 mL/unit plus anticoagulant and preservative in the collection unit
3. Use limited because of advances in the use of blood components

4. Indications
 - a. Acute massive blood loss manifested by signs and symptoms of hypotension, shortness of breath, tachycardia, pallor, and low hemoglobin/hematocrit
 - b. Volume expansion required
 - c. Symptomatic deficit in oxygen-carrying capacity combined with hypovolemia of sufficient degree associated with shock
5. Administration of whole blood is contraindicated when blood loss can be managed with blood components and crystalloid or colloid solutions
6. Disadvantages
 - a. Volume may lead to potential fluid volume excess
 - b. Storage considerations
 - 1) Formation of microaggregates
 - 2) Breakdown of cells resulting in increased potassium level
 - 3) Loss of coagulation factors
 - c. Massive whole blood transfusion may cause calcium deficit in the patient with severely damaged liver
7. Administration considerations
 - a. Check patient's serum potassium before administration
 - b. Number of units administered is determined by the clinical situation
 - c. Administration of a single unit of whole blood is not appropriate
 - d. Administer as rapidly as possible to stabilize hemodynamic status
 - e. For pediatric patients, 20 mL/kg is administered initially, followed by the volume required for hemodynamic stabilization
8. Expected outcome
 - a. Improved hemodynamic status and resolution of symptoms of hypovolemic shock
 - b. Hematocrit and hemoglobin may fluctuate because of rapid fluid shifts during active bleeding and result in erroneous laboratory values
9. Compatibility: must be ABO compatible, unless in an emergency situation when type O may be administered to any other blood group

B. Packed Red Blood Cells (PRBCs)

1. Composition: contains red blood cells (RBCs) and has the same cell mass as whole blood; prepared by separating the plasma from the cellular portion of whole blood
2. Volume: contains 250 to 350 mL/unit depending on anticoagulant/preservative used
3. Indications
 - a. Increase red cell mass when volume expansion is not required
 - b. Restore or maintain oxygen-carrying capacity of the blood
 - c. Symptomatic anemia unresponsive to other therapies
 - d. Hypovolemic shock that can be managed with the administration of RBCs and crystalloid or colloid solutions
 - e. Acute or chronic blood loss with tachycardia, shortness of breath, pallor, fatigue, and low hemoglobin/hematocrit
4. Administration considerations
 - a. Number of units administered is determined by the clinical situation
 - b. Each unit may be infused during a period of 1 to 2 hours but must be infused within 4 hours

- c. Red cells with anticoagulant/preservative solution may be viscous and may require dilution with 0.9% sodium chloride
- d. For pediatric patients
 - 1) Careful consideration must be given prior to transfusion of RBCs to critically ill pediatric and neonatal patients due to increased morbidity and mortality rates based on the high levels of potassium concentration in RBCs resulting in hyperkalemia
 - 2) Usual dose of PRBCs is 10 to 15 mL/kg
 - 3) Units may be divided into aliquots (smaller amounts) for administration
 - 4) Administer as follows:
 - a) First 15 minutes of transfusion, administer 5% to 10% of total transfusion volume, and then
 - b) If no adverse effects, increase administration rate to 2 to 5 mL/kg/hour or as tolerated
- 5. Expected outcome
 - a. Resolution of symptoms of anemia
 - b. Increased hematocrit of 3% and increased hemoglobin of 1 g/dL per unit
- 6. Compatibility
 - a. Must be ABO compatible
 - b. Recipients whose ABO group is unknown may receive group O red cells until ABO type and crossmatching are complete
- 7. Variations of RBCs
 - a. Leukocyte-filtered or leukocyte-reduced
 - 1) A unit of leukocyte-reduced RBCs contains fewer than 5×10^8 leukocytes
 - 2) Indications
 - a) In cases of known febrile, nonhemolytic transfusion reactions caused by donor white cell antigens reacting with recipient white cell antibodies
 - b) To reduce the incidence of urticarial and anaphylactic reactions
 - c) To prevent the transmission of cytomegalovirus (CMV) or alloimmunization to HLAs
 - d) Immunosuppressed patients
 - 3) Reduction methods
 - a) May be performed before or during transfusion
 - b) Filtration: may be done during processing or at bedside; removes as much as 99% of leukocytes
 - 4) Compatibility: must be ABO compatible
 - b. Modified (washed) RBCs
 - 1) Done before transfusion; may reduce number of red cells by 20%; must be used within 24 hours of preparation; the method is more expensive and time-consuming
 - 2) Process to remove platelets, cellular debris, decrease plasma to trace levels, decrease leukocytes
 - 3) Used in patients with recurrent or severe allergic reactions due to one or more plasma proteins and for neonatal and intrauterine transfusions
 - 4) Indications: same as for RBCs
 - 5) Administration: same as for RBCs
 - 6) Compatibility: must be ABO compatible

- c. Frozen-deglycerolized RBCs
 - 1) Composition: contains RBCs and glycerol
 - a) Glycerol is added to the cells before freezing to prevent dehydration and mechanical damage of the cells by ice formation
 - b) Typically glycerized and frozen within 6 hours of donation
 - 2) Blood frozen for long-term storage; up to 10 years
 - 3) Done for autologous donations and to maintain stores of rare blood types
 - 4) Indications: same as for washed RBCs
 - 5) Administration
 - a) Must be thawed in water bath or dry warmer
 - b) Cells are then washed to remove glycerol
 - c) Must be infused within 24 hours of thawing and washing
 - 6) Compatibility: must be ABO compatible

C. Plasma Derivatives

- 1. Fresh frozen plasma (FFP)
 - a. Composition: contains albumin, globulins, antibodies, and clotting factors; prepared by separating plasma from unit of whole blood
 - b. Volume: 200 to 250 mL/unit
 - c. Must be frozen within 8 hours of collection
 - d. Indications
 - 1) Active bleeding with multiple coagulation factor deficiencies
 - 2) Increased level of clotting factors in patients with a demonstrative deficiency
 - 3) Warfarin (Coumadin) reversal
 - 4) Treat disseminated intravascular coagulation (DIC) and evidence of dilutional coagulopathy from large-volume replacement
 - 5) Congenital factor deficiencies for which there are no concentrates (e.g. factors V and XI)
 - 6) Correct acquired deficiency of various coagulation factors due to massive hemorrhage
 - e. Administration considerations
 - 1) Number of units administered is determined by the clinical situation and underlying disease
 - 2) Administer at 200 mL/hour or more slowly if there is potential for circulatory overload
 - 3) For pediatric patients, the usual dose is 10 to 15 mL/kg at a rate of 1 to 2 mL/minute
 - 4) Transfuse within 24 hours of thawing to avoid loss of clotting factors V and VIII
 - 5) FFP expires in 6 hours at room temperature or in 24 hours if refrigerated
 - f. Expected outcome: improved coagulation function
 - g. Compatibility: must be ABO compatible
- 2. Platelets
 - a. Composition: prepared from a single unit of whole blood or plasma
 - 1) Random: single units from multiple donors; usually 4 to 8 units obtained
 - 2) Plateletpheresis: multiple units from a single donor; content equivalent to that of 4 to 8 units from random donors

- b. Indications: thrombocytopenia or abnormal platelet function
 - c. Administration considerations
 - 1) Number of units administered is determined by the clinical situation
 - 2) Infusion rate determined by volume tolerance; may be infused as rapidly as 30 minutes but must be infused within 4 hours
 - 3) Pediatric patients
 - a) Usual dose is 1 unit (50 to 70 mL) per 7 to 10 kg of body weight
 - b) Administer as IV bolus or IV infusion over 30 minutes to 4 hours
 - d. Expected outcome
 - 1) Prevention or resolution of bleeding
 - 2) Increased platelet count
 - e. Compatibility
 - 1) ABO compatibility preferred but not required
 - 2) ABO grouping recommended reducing potential for refractoriness to platelets
 - f. Special considerations
 - 1) Random donor units may be pooled into a single bag before release from blood bank
 - 2) Plateletpheresis units may reduce the risk of transfusion-transmitted diseases and HLA antibody formation
 - g. Platelet variations
 - 1) HLA-matched
 - a) An antigen found on the white cells
 - b) Collected by apheresis from donor who is HLA-compatible with recipient
 - c) Decreases premature destruction of transfused platelets by HLA antibodies
 - d) Frequently used in patients being prepared for tissue/organ transplantation
 - e) Generally more suitable match obtained from immediate family; less perfect match from non-related donor may be sufficient
 - 2) Leukocyte-reduced/leukocyte-filtered
 - a) Reduction achieved by filtration, with approximately 99% of leukocytes being removed
 - b) May occur in the processing phase or by the use of a leukocyte-reduction filter during transfusion
 - c) Used to decrease the incidence of febrile reaction; helps prevent HLA alloimmunization in patients who require long-term platelet support or may require transplantation
3. Cryoprecipitate
- a. Composition: derived from a unit of FFP; rich source of factor VIII (antihemophilia factor), von Willebrand's factor, factor XIII, fibronectin, and fibrinogen
 - b. Only source of fibrinogen
 - c. Volume: each unit contains only 10 to 15 mL of cryoprecipitate and plasma
 - d. Indications
 - 1) Treatment of deficiencies of factor XIII and fibrinogen
 - 2) May be used in the treatment of hemophilia A and von Willebrand's disease if factor VIII concentrate is not available

- e. Administration considerations
 - 1) Number of units is dependent on the clinical situation
 - a) Dose may need to be repeated every 8 to 12 hours
 - b) Laboratory evaluation is required to assess the effectiveness of the treatment
 - 2) Rate of infusion is 1 to 2 mL/min for both adult and pediatric patients
 - 3) Single units must be infused within 6 hours of thawing; pooled units are infused within 4 hours of being pooled
 - 4) 0.9% sodium chloride may be added to the unit to facilitate the recovery of the granulocytes and increase the volume
 - f. Expected outcome
 - 1) Correction of deficiencies
 - 2) Cessation of bleeding episode
 - g. Compatibility: ABO and Rh match is preferred when possible; plasma compatibility is also preferred but not required
4. Albumin
- a. Composition: commercially extracted from plasma; contains no clotting factors; natural plasma protein
 - b. Eliminates risk of transfusion-transmitted viruses
 - c. Role in regulating plasma volume and tissue fluid balance
 - d. Available in 5% (isotonic) or 25% (hypertonic) solution concentrations
 - e. Indications
 - 1) Volume expansion when crystalloid solutions are not adequate
 - 2) Treatment of hypoproteinemia
 - 3) 5% concentration is used as the plasma substitute in the treatment of hypovolemic shock and massive hemorrhage
 - 4) 25% concentration is usually used when there are fluid or sodium restrictions
 - 5) Contraindicated in patients with cardiac failure, severe anemia, or known hypersensitivity
 - f. Administration considerations
 - 1) Amount administered is dependent on the clinical situation
 - a) 5% solution (50 mg/mL): isotonic solution oncologically equivalent to plasma; available in 50, 250, 500, or 1,000 mL vials
 - b) 25% solution (250 mg/mL); available in 20, 50, and 100 mL vials
 - 2) Rate and volume of administration vary depending on indication, current blood volume, and patient response; circulatory overload may occur if albumin is infused too rapidly
 - 3) Use straight-line set to administer
 - g. Expected outcome
 - 1) Expansion of blood volume
 - 2) Prevention of marked hemoconcentration
 - 3) Decreased edema
 - 4) Increased serum protein levels
 - h. Compatibility: crossmatching is not necessary
5. Plasma protein fraction
- a. Composition: commercially extracted from plasma; contains a high degree of plasma products and no clotting factors
 - b. Indications
 - 1) Plasma volume expansion in the treatment of shock or in conditions in which circulatory volume deficit is present

- c. Administration considerations
 - 1) Rate and dose are dependent on patient's condition and response to therapy; however, administration should not exceed 10 mL/min to reduce the potential for a hypotensive episode
 - 2) Available as a 5% solution
- d. Expected outcome
 - 1) Expansion of plasma volume
 - 2) Prevention of marked hemoconcentration
 - 3) Decreased edema
 - 4) May increase serum protein levels
- e. Compatibility: crossmatching not necessary

D. Clotting Factor Components

- 1. Factor VIII
 - a. Commercially prepared from large pools of donor plasma
 - b. Indications
 - 1) Factor VIII deficiency (hemophilia A)
 - 2) Replace fibrinogen or factor VIII
 - c. Administration considerations
 - 1) Amount to be administered depends on prophylactic use or as treatment for active bleeding
 - 2) Dilution is required for reconstitution and should be administered within 3 hours of reconstitution
 - 3) Standard dose for acute bleeding episodes is 15 to 20 units/kg
 - 4) Use administration set and filter supplied by manufacturer
 - 5) Administer as rapidly as tolerated; do not exceed 6 mL/minute
 - 6) Some preparations can be used to treat von Willebrand's disease
 - 7) Factor assays should be performed at appropriate intervals to assess the response
 - d. Expected outcome: hemostasis is achieved due to increased levels of factor VIII or von Willebrand's factor activity
 - e. Compatibility: ABO compatibility preferred but not required
- 2. Factor IX concentrate
 - a. Commercially prepared from quantities of donor plasma; may also contain trace amounts of factors II, VII, and X
 - b. Indications: factor IX deficiency (hemophilia B), also known as Christmas disease
 - c. Administration considerations
 - 1) Amount to be administered depends on the clinical situation and should be based on the patients' body weight and desired blood level
 - 2) Recommended dose and treatment schedule vary with the severity and type of bleeding
 - 3) Diluent is provided with the factor for reconstitution
 - 4) Can be given by IV injection or IV drip
 - 5) Factor assays should be performed at intervals to assess the response
 - 6) Use straight-line set to administer
 - d. Expected outcome: hemostasis due to increased level of factor IX activity
 - e. Compatibility: ABO compatibility or Rh matching not required

E. Rh Immune Globulin

1. Five classes of antibodies with immunoglobulin G (IgG) being the major immunoglobulin in the blood
2. IgG antibodies are involved in secondary immune response
3. Antibody molecules bind to many types of pathogens such as viruses, bacteria, and fungi, and protect the body against them by agglutination and immobilization
4. Indications
 - a. Treat immunodeficiency disorders
 - b. Patients exposed to Rh (D) antigens through transfusions or pregnancy
 - c. Used to provide immunity following hepatitis B exposure
5. Administration considerations
 - a. Usually given IV or IM
 - b. IM injections can be painful so warm compresses may assist in alleviating the discomfort
 - c. Timeline of administration is based on the reason for treatment and/or exposure
 - 1) Rh (D) antigen exposure through transfusion or pregnancy—administer within 72 hours to achieve the maximum effect
 - 2) Hepatitis B exposure—administer as soon as possible after exposure to achieve maximum effect
6. Can have allergic or anaphylactoid reactions

F. Granulocytes

1. Composition: neutrophils, basophils, and eosinophils
2. First-line of defense against infecting organisms
3. Contains leukocytes, platelets, and some RBCs in 200 to 300 mL of plasma
4. Transfuse as soon as possible after collection but can be stored up to 24 hours
5. Obtain from CMV negative donors to decrease the risk of CMV
6. Indications
 - a. Neutropenia ≤ 500 /microliter
 - b. Myeloid hypoplasia
 - c. Hematopoietic stem cell transplantation
 - d. Fever unresponsive to antibiotics or other modes of therapy
 - e. Delayed or slow neutrophil recovery
 - f. Aplastic anemia
 - g. Neonatal sepsis
 - h. AABO states infants with all of the following conditions are candidates for granulocyte transfusion:
 - 1) Strong evidence of bacterial sepsis
 - 2) Absolute neutrophil count below 3,000 microliter
 - 3) Diminished marrow storage pool
7. Should be irradiated to decrease risk of GVHD
8. Administration considerations
 - a. Require blood administration set
 - b. Do not agitate
 - c. Do not infuse through leukocyte-reduction filter
 - d. Infuse over 1 to 2 hours
 - e. No consensus on specific effective dose

9. Expected outcomes
 - a. Increase peripheral white blood cell (WBC) count
 - b. Resolution of neutropenia
10. Compatibility
 - a. Donors must be ABO compatible due to the high number of RBCs in the granulocyte concentrate



IV. Adverse Reactions

A. Acute (occurs within minutes or hours of administration)

1. Hemolytic
 - a. Intravascular hemolysis
 - 1) Causes
 - a) Donor red cells incompatible with recipient's plasma; potential fatality may occur with the administration of as little as 10 to 15 mL of incompatible blood
 - b) Misidentification or improper labeling, resulting in the administration of blood with the wrong ABO blood group
 - 2) Signs and symptoms
 - a) Fever with or without chills
 - b) Hypotension
 - c) Lumbar pain
 - d) Hemoglobinemia
 - e) Hemoglobinuria
 - f) Dyspnea
 - g) Shock
 - h) Oliguria or anuria
 - i) Abnormal bleeding
 - 3) Interventions
 - a) Stop transfusion
 - b) Change administration set and administer 0.9% sodium chloride at a rate to maintain patent vascular access
 - c) Notify the licensed independent practitioner (LIP) and blood bank immediately
 - d) Institute transfusion reaction protocol
 - e) Initiate treatment to reverse the effects of reaction
 - 4) Preventive measures
 - a) Proper patient identification
 - b) Proper labeling of blood sample
 - c) Verification of ABO/Rh compatibility between donor and recipient before administration
 - b. Extravascular hemolysis
 - 1) Causes
 - a) Donor plasma incompatible with recipient's red cells
 - b) Improperly identified blood sample, blood unit, or patient
 - 2) Signs and symptoms
 - a) Chills
 - b) Fever, usually several hours after transfusion
 - c) Positive direct antiglobulin test

- 3) Interventions
 - a) Stop transfusion
 - b) Change administration set and administer 0.9% sodium chloride at a rate to maintain patent vascular access
 - c) Notify LIP and blood bank immediately
 - d) Institute transfusion reaction protocol
 - e) Initiate treatment to relieve symptoms
- 4) Preventive measures
 - a) Proper patient identification
 - b) Proper labeling of blood sample
2. Febrile nonhemolytic (FNH) reaction
 - a. Most common type of transfusion reaction
 - b. Cause: WBC antigen–antibody reaction
 - c. Signs and symptoms
 - 1) Increase in temperature of 1 °C or 2 °F or more without any other clinical reason; may begin early in transfusion or as long as several hours after completion
 - 2) Chills
 - 3) Rigors
 - 4) General malaise
 - d. Interventions
 - 1) Stop transfusion
 - 2) Change administration set and administer 0.9% sodium chloride at a rate to maintain patent vascular access
 - 3) Notify LIP and blood bank
 - 4) Institute transfusion reaction protocol
 - 5) Administer antipyretics, as ordered, to treat fever
 - e. Preventive measures
 - 1) Obtain transfusion history
 - 2) Premedicate, as ordered
 - 3) Use of leukocyte-reduced products
3. Transfusion-related acute lung injury (TRALI)
 - a. Causes
 - 1) Undetermined but two theories are projected
 - a) Antibody reaction
 - b) Infusion of biologic response modifiers
 - 2) All plasma-containing blood products have been reported to cause TRALI
 - 3) Antibodies, such as HLA and human neutrophil antigens, have been identified as antibodies associated with TRALI
 - a) In the majority of TRALI cases, the antibody was present in the transfused blood product
 - b) Research has determined that the majority of blood donors with HLA antibodies are multiparous females
 - b. Severe life-threatening adverse reaction
 - c. Leading cause of transfusion-related mortality (5% to 15% rate)
 - d. Symptoms typically occur within 6 hours of infusion but majority of reactions are seen within 1 to 2 hours of transfusion
 - e. Signs and symptoms
 - 1) Most common: acute respiratory distress and hypo/hypertension
 - 2) Dyspnea
 - 3) Cyanosis

- 4) Chills
- 5) Cough
- 6) Bilateral pulmonary edema
- f. Diagnosis
 - 1) No specific diagnostic tests that can confirm TRALI
 - 2) Based on signs and symptoms
 - 3) Diagnosis is a process of exclusion
 - 4) Normal central vascular and pulmonary wedge pressure along with the absence of jugular distention are consistent with the diagnosis of TRALI
 - 5) Fever and skin manifestations are not symptoms seen in TRALI
 - 6) Transient leukopenia associated with TRALI
- g. Interventions
 - 1) No specific treatment
 - 2) Notify LIP and blood bank
 - 3) Appropriate respiratory support
 - a) Majority require oxygen supplementation
 - b) Severe cases may require intubation and mechanical ventilation
 - 4) Maintain patent vascular access
- h. Preventive measures
 - 1) No standards or regulations exist for TRALI
 - 2) In 2007, blood centers began decreasing the amount of plasma provided by the female donors
 - 3) Some blood centers only provide plasma from male donors
 - 4) AABB recommends minimizing transfusion of plasma from leukocyte-alloimmunized donors
 - 5) No consensus or measures to decrease the risk of TRALI from apheresis platelets, which contain about 250 mL of plasma
- 4. Allergic
 - a. Cause: sensitivity reaction to foreign plasma protein in transfused product
 - b. Signs and symptoms
 - 1) Urticaria
 - 2) Hives
 - 3) Local erythema
 - c. Interventions: based on the severity of the reaction
 - 1) Severe
 - a) Stop transfusion
 - b) Notify LIP and blood bank
 - c) Initiate treatment to relieve symptoms, as ordered
 - 2) Mild
 - a) Interrupt transfusion
 - b) Administer antihistamines, as ordered
 - c) After resolution of symptoms, proceed with transfusion
 - d. Preventive measures
 - 1) Obtain transfusion history
 - 2) Pretreatment with an antihistamine may be ordered
- 5. Anaphylaxis
 - a. May occur after infusion of only a few milliliters of blood or plasma
 - b. Cause: generally unknown but thought to be associated with sensitization to a foreign protein

- c. Signs and symptoms
 - 1) Respiratory distress
 - 2) Bronchospasm
 - 3) Abdominal cramps
 - 4) Nausea, vomiting, or diarrhea
 - 5) Shock
 - 6) Loss of consciousness
 - 7) Death
- d. Interventions
 - 1) Stop transfusion
 - 2) Maintain patent vascular access
 - 3) Notify LIP and blood bank
 - 4) Initiate treatment to relieve symptoms
- e. Preventive measures
 - 1) Obtain transfusion history
 - 2) Use of deglycerolized red cells or autologous blood for future transfusions
- 6. Transfusion-associated circulatory overload (TACO)
 - a. Cause: rapid infusion to patients with compromised cardiac or pulmonary status
 - b. Patients at risk for TACO should have blood transfused at a reduced rate; to prevent overload administer blood at a rate of 1 mL/kg body weight/hour which is about 4 hours/unit
 - c. Signs and symptoms
 - 1) Pulmonary edema
 - 2) Dyspnea
 - 3) Cyanosis
 - 4) Severe headache
 - 5) Hypertension
 - d. Interventions
 - 1) Stop transfusion and maintain patent vascular access
 - 2) Notify LIP and blood bank
 - 3) Place patient in sitting position
 - 4) Administer diuretics and oxygen, as ordered
 - e. Preventive measures: infuse blood and blood components at a rate appropriate for patient's condition, age, and tolerance to treatment
- 7. Bacterial contamination
 - a. Cause: introduction of bacteria at the time of donation or component preparation; gram-negative organisms are most commonly involved; occurs rarely
 - b. Signs and symptoms
 - 1) High fever
 - 2) Hypotension
 - 3) Flushing of the skin
 - 4) Shock
 - 5) Renal failure
 - 6) DIC
 - c. Interventions
 - 1) Stop transfusion and remove blood administration set, filter, blood component unit and 0.9% sodium chloride flush bag; send to blood bank for culture

- 2) Prepare new administration set with 0.9% sodium chloride and administer at a rate to maintain patent vascular access
- 3) Initiate measures to prevent shock
- 4) Notify LIP and blood bank
- 5) Obtain blood cultures
- d. Preventive measures: use aseptic technique and sterile equipment in the collection, processing, and administration of blood components
8. Hypothermia
 - a. Cause: rapid infusion of refrigerated blood or blood components
 - b. Signs and symptoms
 - 1) Shaking chills
 - 2) Hypotension
 - 3) Cardiac arrhythmias
 - c. Interventions
 - 1) Initiate measures to warm blood
 - 2) Initiate treatment to relieve symptoms
 - d. Preventive measures: warm blood using a fluid/blood warming device
9. Citrate toxicity
 - a. Cause: high citrate load present in large volume transfusion
 - b. Citrate metabolized by liver
 - c. Recipients with liver impairment may be unable to manage the high citrate load associated with a large volume transfusion
 - d. Signs and symptoms
 - 1) Hypocalcemia
 - 2) Circumoral tingling
 - 3) Hypotension
 - 4) Nausea and vomiting
 - 5) Hypokalemia
 - 6) Cardiac arrhythmias
 - e. Interventions
 - 1) Slow or discontinue transfusion
 - 2) Monitor serum calcium and potassium levels
 - f. Preventive measures: ascertain history of liver impairment
10. Potassium toxicity
 - a. Cause: leakage of potassium from RBCs during storage which increases serum potassium after transfusion
 - b. Nonimmune-mediated adverse reaction
 - c. Development of electrolyte excess or toxicity with transfusion or repeated blood transfusions
 - d. Neonates and patients with renal failure have increased risk of potassium toxicity
 - e. Signs and symptoms
 - 1) Muscle weakness
 - 2) Nausea/vomiting
 - 3) Cardiac/ECG changes
 - f. Interventions
 - 1) Monitor serum potassium levels
 - 2) Notify LIP
 - g. Preventive measures
 - 1) Ascertain a history of renal disease and chronic transfusions

B. Delayed (onset within days to years)

1. Primary alloimmunization
 - a. Cause: sensitization to foreign RBC antigens not found in the ABO system; examples include Rh, Kell, Duffy, and Kidd antigens
 - b. Signs and symptoms
 - 1) Fever of unknown origin
 - 2) Continued anemia
 - 3) Decreased hemoglobin
 - 4) Mild jaundice
 - 5) Hemoglobinuria
 - c. Interventions: monitor renal function
2. Secondary alloimmunization
 - a. Cause: re-exposure to an antigen, increasing antibody production
 - b. Signs and symptoms
 - 1) Fever
 - 2) Unexpected drop in hemoglobin
 - 3) Mild jaundice
 - 4) Hemoglobinuria
 - c. Interventions: monitor renal function
 - d. Preventive measures: administer future transfusions that do not contain the corresponding antigen
3. Iron overload
 - a. Cause: progressive and continued accumulation of iron as a result of chronic transfusions, especially in patients with hemoglobinopathies
 - b. Each unit of RBCs contains approximately 200 to 250 mg iron
 - c. Affects organs such as liver, heart, pancreas, pituitary, and parathyroid glands
 - d. Damage to organs occurs long before clinical symptoms appear
 - e. Body has no mechanism to excrete iron
 - f. Prognosis poor without iron chelation therapy
 - g. Signs and symptoms
 - 1) Hepatic failure
 - 2) Cardiac toxicity
 - 3) General fatigue
 - 4) Weight loss
 - 5) Bronze/gray skin
 - h. Identifying iron overload
 - 1) Determine number of RBC transfusions received
 - 2) CT scan or MRI
 - 3) Liver or endomyocardial biopsy—gold standard
 - 4) Monitor serum ferritin—the most common test to check for iron burden
 - i. Interventions
 - 1) Decrease or remove iron without reducing the circulating hemoglobin
 - 2) Chelation therapy
 - a) Deferoxamine mesylate (Desferal)—subcutaneous or IV infusion over 8 to 12 hours for 5 to 7 days
 - b) Deferasirox
 - Oral iron chelator approved for ages 2 or older
 - Dose: 20 to 30 mg/kg tablet per day as single or divided dose
 - Dissolve tablet in liquid and give on an empty stomach; wait 30 minutes before ingesting food

4. TA-GVHD
 - a. Cause: infusion of immunocompetent lymphocytes into a severely immunosuppressed recipient
 - b. Condition fatal in 90% to 100% of cases
 - c. Signs and symptoms
 - 1) Fever
 - 2) Skin rash
 - 3) Hepatitis
 - 4) Diarrhea
 - 5) Bone marrow suppression
 - 6) Overwhelming infection that may progress to fatal outcome
 - d. Interventions: initiate treatment of symptoms
 - e. Preventive measures: pre-transfusion irradiation of all blood components containing lymphocytes
5. Transfusion transmitted diseases
 - a. Hepatitis: viruses associated with post-transfusion are hepatitis B and hepatitis C
 - 1) Cause: transmission of hepatitis virus from donor to recipient
 - 2) Signs and symptoms: can occur from 2 weeks to 6 months after transfusion
 - a) Abnormal liver function test
 - b) Elevated liver enzymes
 - c) Fatigue
 - d) Nausea
 - e) Jaundice
 - 3) Intervention: initiate treatment of symptoms
 - 4) Preventive measures: careful screening of and thorough history from donors to reduce incidence
 - b. Human T-cell lymphotropic virus (HTLV)
 - 1) Cause: transmission of HTLV from donor to recipient
 - 2) Four types of HTLV are identified
 - 3) HTLV-III is the type that causes acquired immunodeficiency syndrome
 - 4) Signs and symptoms
 - a) Fever
 - b) Night sweats
 - c) Weight loss
 - d) Skin lesions
 - e) Adenopathy
 - f) Opportunistic infections
 - 5) Interventions: initiate treatment of symptoms
 - 6) Preventive measures: careful screening of and thorough history from donors help reduce the incidence
 - c. Cytomegalovirus (CMV)
 - 1) Cause: member of the herpes virus family; known to be one of the infectious agents most frequently transmitted by transfusion
 - 2) Immunocompromised patients are at greater risk for morbidity and mortality associated with transfusion-acquired CMV
 - 3) Signs and symptoms
 - a) Most CMV infections are asymptomatic
 - b) May have mononucleosis-like syndrome
 - 4) Interventions: initiate treatment of symptoms

- 5) Preventive measures: careful screening of and thorough history from donors to reduce the incidence
6. Transfusion-related immunomodulation (TRIM)
 - a. Cause: results from infusion of foreign antigens and proteins that accumulate in blood products during storage
 - b. Recipients of blood products develop downregulation of their immune system after the infusion of donor antigens and proteins; direct pathophysiology unknown
 - c. No consensus on pathophysiology of TRIM
 - d. One of the common causes of transfusion-associated morbidity and mortality
 - e. Effects of TRIM
 - 1) Benefits
 - a) Reduced recurrence of Crohn's disease
 - b) Enhanced renal allograft survival
 - 2) Adverse
 - a) Hemolytic transfusion reaction
 - b) TRALI/GVHD
 - c) CMV or HIV infections
 - d) Increased risk of bacterial/nosocomial infections
 - e) Increased risk of malignant recurrence
 - f) Multiple organ failure
 - f. Signs and symptoms: based on the type of TRIM effect that occurs (see Effects above)
 - g. Interventions/preventive measures: unresolved issues with further research are needed to determine the components that may mediate TRIM along with potential interventions and preventive measures



V. Patient Assessment

A. History

1. Pertinent medical history: includes current and chronic conditions and medications
2. Transfusion history: includes any reactions or adverse effects experienced during previous transfusions
3. Social history: includes religious and cultural beliefs

B. Clinical Assessment

1. Review of laboratory values for appropriateness of therapy
 - a. Hematocrit
 - b. Hemoglobin
 - c. Platelets
 - d. Electrolytes, especially calcium and potassium
 - e. Liver function tests
 - f. Albumin
 - g. Clotting factor assays
 - h. Serum iron binding
2. Vital signs: abnormal findings before the start of a transfusion may delay recognition of a transfusion reaction
3. Renal status: determine function

4. Adequacy of vascular access
5. Mental status: ability to comprehend or cooperate before and during transfusion



VI. Pre-Administration

A. LIP Transfusion Order

1. Type of component and number of units to be administered
2. Premedication orders, as appropriate
3. Special considerations, such as leukocyte-reduced components, blood warmer, etc.

B. Informed Consent

1. Must be signed before administration of blood and blood components
2. LIP is responsible for informing the patient of benefits, risks, alternative treatments, and prognosis

C. ABO, Rh determination: type and crossmatching must be done, as appropriate

D. Patient education: discuss the purpose of transfusion, benefits, and risks involved

E. Identification/Verification

1. Obtain blood or blood components from the blood bank/transfusion services; verification of patient identification and results of ABO and Rh compatibility are essential before removing blood products from blood bank/transfusion services
2. Verify patient identification: before initiating the transfusion, the following information must be verified at the bedside by two qualified clinicians:
 - a. Patient name
 - b. Identification number
 - c. Type of component
 - d. Donor and recipient's ABO and Rh type
 - e. Expiration date of unit
 - f. Compatibility results
 - g. Blood component number



VII. Administration

A. Special Considerations

1. 0.9% sodium chloride is the only solution for use with blood administration; other solutions may potentiate agglutination or hemolysis if used with blood
2. A nonvented blood administration set must be used to reduce the potential for air contamination

3. Blood must be stored in blood bank-approved, temperature-controlled refrigeration units
4. Blood must be returned to the blood bank within 30 minutes if the transfusion cannot be initiated
5. When required, blood is warmed only using a specifically designed blood/fluid warmer
6. Blood should be administered within 4 hours; units may be split into aliquots if longer hang time is required because of patient's condition or age
7. No medications should be added to blood
8. Blood must be filtered
9. Blood should not be piggybacked into an administration set that has been used for any solution other than 0.9% sodium chloride

B. Storage/Time Limitations

1. Whole blood or PRBCs—shelf-life of 35 to 42 days if additive solutions have been added
2. Washed RBCs—shelf-life of 24 hours after washing; must be administered within 24 hours of washing
3. Granulocytes—should be transfused as soon as possible after collection but can be stored up to 24 hours
4. FFP—can be stored up to 1 year; administer within 24 hours of thawing
5. Platelets—store with gentle agitation at room temperature for as long as 5 days; must be transfused within 6 hours of pooling
6. Cryoprecipitate—must be transfused within 6 hours of thawing or 4 hours of pooling

C. Equipment

1. Vascular access device
 - a. Acceptable intravenous catheter sizes range from 22- to 14-gauge; generally recommended that blood/blood components be transfused through 18 to 20-gauge catheter
 - b. Consideration can be given to use a 22- to 24-gauge for pediatric patients or patients with small veins that do not need rapid flow rates
2. Filters
 - a. Designed to retain clots and other debris from the blood/blood components and prevent them from being administered to the patient
 - b. Types
 - 1) Standard: 170 to 260 microns
 - 2) Microaggregate: 20 to 40 microns; recommended for administration of whole blood or packed cells that have been stored for 5 or more days and in cardiopulmonary bypass surgery; may impede flow rates when rapid transfusion is required
 - 3) Leukocyte reduction: specifically designed for red cells or platelets; removes at least 99% of leukocytes from the component
 - c. To maximize the effectiveness, it is important that the whole surface area of the filter be used
 - d. May be an integral part of the blood administration set or be added to a nonvented administration set

3. Blood administration sets
 - a. Straight: designed to administer a single unit; not recommended for use when multiple units are to be administered
 - b. Y-type: designed for the administration of multiple units; one arm of the Y is designated for the administration of 0.9% sodium chloride; the other arm is designated for the blood
 - c. Component recipient set: designed for the administration of platelets and cryoprecipitate; generally of a shorter length and a smaller filter surface area to reduce the lysis of the component
 - d. Component infusion set: designed to allow for administration of components by direct intravenous push
4. Electronic infusion device
 - a. Consideration must be given to the configuration of the pumping mechanism and to the pounds per square inch of pressure to minimize the risk of damage to the cells
 - b. Follow manufacturers' recommendation for use with blood/blood components
5. External pressure cuff
 - a. Designed to assist in the delivery of blood by exerting even pressure to the bag
 - b. Cuff must have a gauge to monitor pressure; pressure should not exceed 300 mmHg
 - c. Not used routinely; may be used in situations in which rapid administration is required
 - d. Use of external pressure to administer a transfusion through a small-gauge catheter may result in damage to the red cells
6. Blood/fluid warmer
 - a. Device that increases the temperature of the blood or blood components
 - b. Indications
 - 1) Rapid massive infusion of refrigerated blood
 - 2) Exchange transfusion in newborns
 - 3) In patients with known potent cold agglutinins
 - c. Types
 - 1) Warm water bath: blood passes through coiled plastic tubing placed in a monitored water bath
 - 2) Electric heated plates: blood passes through a plastic bag that has been placed between electronically heated plates
 - d. All blood warmers must have a temperature gauge; recommended temperature is 32°C to 37°C; hemolysis may occur if temperature exceeds 42°C
 - e. Warmer must be equipped with an audible alarm system
 - f. Use of warmer may decrease the flow rate and may increase the amount of priming fluid required

D. Documentation

1. Documentation of transfusion therapy begins during the initial assessment and continues through completion of transfusion
2. The documentation of the transfusion event should be made in the patient's permanent medical record
3. At minimum, AABB standards requires the following documentation:
 - a. Order for transfusion
 - b. Documentation of the recipient consent

- c. Name or type of the component
- d. Donor unit or pool identification number
- e. Date and time of transfusion
- f. Pre- and post-transfusion vital signs
- g. Volume transfused
- h. Any adverse events possibly related to the transfusion
- 4. Pre-administration
 - a. Verification of the transfusion order
 - b. Completed transfusion consent form
 - c. Patient teaching
 - d. Placement of vascular access device or assessment of indwelling VAD
 - e. Vital signs
 - f. Identification/verification of patient/blood component by two qualified clinicians
 - g. Initials, signature, and credentials of clinicians involved with the transfusion
- 5. Administration
 - a. Date/time of initiation of transfusion
 - b. Patient's tolerance to the first 15 minutes of transfusion
 - c. Vital signs
 - d. Assessment of patient for signs/symptoms of possible transfusion reaction during infusion
 - e. If reaction noted, specify
 - 1) Clinical symptoms
 - 2) When transfusion stopped
 - 3) Notification of LIP and blood bank
 - 4) Nursing interventions and response to intervention
 - 5) Patient teaching
- 6. Post-administration
 - a. Date/time of completion of transfusion
 - b. Blood volume received
 - c. Vital signs
 - d. Patient tolerance to transfusion
 - e. Flush and lock VAD if it is to remain in place
 - f. Patient teaching

BIBLIOGRAPHY

- AABB (2012). *Standards for blood banks and transfusion services* (28th ed.). Bethesda, MD: Author.
- Brownlee, J., Carson, S., & McKiernan, P. (2010). Nursing considerations in the management of patients with chronic transfusional iron overload. *Oncology Nurse Advisor*, (Supplement), 1–16. Retrieved from <http://www.oncologynurseadvisor.com/nursing-considerations-in-the-management-of-patients-with-chronic-transfusional-iron-overload/article/167777/2/>.
- Cannon-Diehl, M. R. (2010). Transfusion in the critically ill. Does it affect outcome? *Critical Care Nursing Quarterly*, 33(4), 324–338.
- Clark, C. (2011). Recent efforts and available technologies for safety in delivery of blood products. *Journal of Infusion Nursing*, 34(1), 23–37.
- DomBourian, M., & Holland, L. (2012). Optimal use of fresh frozen plasma. *Journal of Infusion Nursing*, 35(1), 28–32.
- Eckes, E. J. (2011). Chelation therapy for iron overload. *Journal of Infusion Nursing*, 34(6), 374–380.
- Elebute, M., Massey, E., Benjamin, S., Stanworth, S., Navarrete, C., & Lucas, G. (2011). Clinical guidelines for use of granulocyte transfusions. Retrieved from http://hospital.blood.co.uk/library/pdf/INF276_2.pdf
- Harris, D. J. (2009). The resurgence of granulocyte transfusions. *Journal of Infusion Nursing*, 32(6), 323–329.

- Infusion Nurses Society. (2011). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S1–S110.
- Katz, E. (2009). Blood transfusion: Friend or foe. *AACN Advanced Critical Care*, 20(2), 155–163.
- Kopko, P. (2010). Transfusion-related acute lung injury. *Journal of Infusion Nursing*, 33(1), 32–37.
- LaCroix, J., Hébert, P. C., Hutchison, J. S., Hume, H. A., Tucci, M., Ducruet, T., ... Pediatric Acute Lung Injury and Sepsis Investigators Network. (2007). Transfusion strategies in the pediatric intensive care unit. *The New England Journal of Medicine*, 356(16), 1609–1619.
- Phillips, L. D. (2010). *Manual of I.V. therapeutics: Evidence-based practice for infusion therapy* (5th ed., pp. 696–788). Philadelphia, PA: F.A. Davis.
- Sink, B. L. S. (2008). Administration of blood components. In J. D. Roback, M. R. Combs, B. J. Grossman, & C. D. Hillyer (Eds.), *American Association Of Blood Banks Technical Manual* (17th ed., pp. 617–629). Bethesda, MD: American Association of Blood Banks Press.
- Trick, N. L. (2010). Blood component therapy. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 242–262). St. Louis, MO: Saunders/Elsevier.
- Wakhine, Y. (2011). *FDA approves Deferiprone for iron overload*. Retrieved from http://www.medscape.com/viewarticle/751573?sssdmh=dm1.725828&src=nl_newsalert
- Zacchero, M., & Bucher, D. (2010). Establishing evidence-based transfusion education for best practice. *Nursing 2010 Critical Care*, 5(5), 41–44.
- Zacchero, M. M., & Zacchero, M. (2010). Red blood cell transfusion in the intensive care unit (ICU). *Nursing 2010 Critical Care*, 5(4), 13–16.

Antineoplastic and Biologic Therapy

Lynn M. Czaplewski, MS, RN, ACNS-BC, CRNI®, AOCNS®

Cora Vizcarra, MBA, RN, CRNI®

PART I: ANTINEOPLASTIC THERAPY



I. Overview

- A. Antineoplastic therapy in the treatment of cancer includes the use of chemotherapy agents and biotherapy
- B. Chemotherapy agents directly kill cancer cells as well any cells in the body that replicate frequently
- C. Biotherapy in the treatment of cancer includes biologic response modifiers, gene therapy, monoclonal antibodies, and anti-angiogenic agents



II. The Cell Cycle

A. Overview

- 1. The cell cycle is a series of phases in normal and cancer cell growth resulting in cell division into two daughter cells
- 2. The knowledge of cell growth and division helps in the understanding of the mechanisms of action and side effects of antineoplastic therapy

B. Cell Cycle of Normal Cells

- 1. After cell division, the daughter cells either execute the programmed functions of a specific tissue or enter the cell cycle again to reproduce

2. Normal cells in the resting stage reenter the cell cycle and reproduce only when necessary
3. A control mechanism prevents cell replication unless a cell needs to be replaced as a result of damage or death
4. The cell cycle consists of five stages or phases
 - a. G_0 : resting stage, in which the cell is not dividing; it may reenter the cell cycle to replicate
 - b. G_1 : stage of ribonucleic acid (RNA) and protein synthesis
 - c. S: stage of deoxyribonucleic acid (DNA) synthesis
 - d. G_2 : pre-mitotic stage (manufactures mitotic spindle)
 - e. M: mitosis stage (actual cell division)
5. Cell cycle time is the length of time needed for a cell to replicate

C. Cancer Cell Development

1. Cancer cells possess characteristics that allow for uncontrolled cell division
2. Cancer cells continue to divide avoiding normal cell death (apoptosis) resulting in tumor growth and spread into surrounding tissues
3. The cancer cell mass is composed of cells that are dividing or resting
 - a. The percentage of dividing cancer cells is called the “growth fraction”
 - b. The term “tumor burden” refers to the number of cancer cells in the body



III. Drug Specificity

A. Overview

1. Most chemotherapeutic agents exert the greatest kill of cell when cells are actively dividing. Both malignant cells and normal cells are affected.
 - a. The smaller the cancer cell mass, the more the cell division is occurring
 - b. The smaller the mass, the more effective the agent
2. Antineoplastic agents cannot distinguish cancer cells from normal cells
 - a. Normal cells that are frequently dividing are found in the bone marrow, gastrointestinal (GI) tract, mucosa, gonads, and hair follicles
 - b. Side effects from the agents result from damage to these tissues: myelosuppression, nausea, vomiting, diarrhea, mucositis, infertility, and alopecia
3. The ideal dose of an antineoplastic agent is one that maximizes cell kill without life-threatening toxicities; time is allowed between cycles to allow normal cells to recover
4. Treatment is determined by the type and stage of the cancer as noted in a pathology report and by the patient's performance status
5. Chemotherapeutic agents are categorized by their effect on the cell cycle
 - a. Cell cycle-specific agents exert their greatest effect on one or more phases in the cell cycle
 - b. Cell cycle-nonspecific agents exert their effect on all phases of the cell cycle

B. Cell cycle-specific Agents

1. Act on the cells at various phases of the cell cycle, for example, inhibit mitosis (vinca alkaloids), interfere with DNA synthesis, or prevent cell reproduction (antimetabolites)
2. Most effective when a large number of cells are dividing

C. Cell cycle-nonspecific Agents

1. Act on cells that are not going through the division phase
2. Prevent cell division by causing chromosome breakage and formation of new cellular DNA (alkylating agents)
3. Interfere with cell division, destroying completed DNA and inhibiting transcription of RNA (antitumor antibiotics)
4. Act nonselectively on cancer cells (nitrosoureas)



IV. Investigational Agents and Protocols

A. Overview

1. Clinical investigation of new antineoplastic agents is accomplished in four phases
2. The agent becomes commercially available after successful completion of Phase III

B. Phases and Goals of Clinical Trials

1. Phase I: To determine the pharmacokinetics of the agent, the maximum tolerated dose, the dose range, and dose-limiting toxicities; about 20 to 80 participants
2. Phase II: To determine the antitumor activity for a specific type of cancer or cancers; to determine the common short-term side effects, risks, and safety; about 100 to 300 participants
3. Phase III: To compare the new agent(s) with the usual treatment protocol(s), to confirm the effectiveness and monitor the side effects; about 1,000 to 3,000 participants; after the Phase III trial, FDA approval is sought
4. Phase IV: To determine the risks, benefits, optimal use, and long-term safety in post-marketing studies

C. Components of a Clinical Trial Protocol

1. Background information about the study
2. Objectives
3. Patient selection criteria
4. Schema (identifies arms of the study and regimens to be tested)
5. Toxicity information
6. Required laboratory and diagnostic procedures
7. Evaluation parameters
8. Informed consent
9. References
10. Resource person and contact information

D. Institutional Review Board (IRB)

1. All investigational agents, studies, and protocols must be approved by an IRB
2. The objective of the IRB is to protect human participants and to oversee the informed consent process
3. Membership and actions of the IRB are determined and monitored by federal regulations

E. Informed Consent

1. Risks, benefits, purpose, length of the study, and required procedures are explained prior to participant signing the agreement
2. Patient may withdraw from the study at any time

F. Policies and Procedures

1. Organizational policies and procedures must be followed
2. National standards are references for the development of the procedures

G. Nursing Responsibilities in Clinical Trials

1. Ensure informed consent
2. Follow protocol precisely
3. Monitor patient per protocol
4. Documentation
 - a. Record toxicities according to severity scale
 - b. Record response to therapy
5. Support patient



V. Preadministration Considerations

A. Patient History

1. Medical history
 - a. Cardiac, respiratory, renal, hepatic, and GI
 - b. Other conditions (e.g., diabetes mellitus)
 - c. Allergies: food, drug, bee stings, and latex
 - 1) Patients with allergies to bees are at increased risk for sensitivity reactions to chemotherapy agents and biotherapies
 - d. Prior history of cancer and cancer treatment: chemotherapy, radiation therapy, biotherapy, hormonal therapy, complementary, and/or alternative treatment
2. Surgical history
 - a. Procedures related to cancer diagnosis (e.g., hemicolectomy for colon cancer)
 - b. Other surgical procedures
3. Menstrual history and pregnancies
4. Psychosocial history
 - a. Psychiatric history
 - b. Marital status and children
 - c. Current living situation (home, apartment, nursing home, or homeless)
 - d. Transportation needs
 - e. Financial issues
 - f. Need for referrals (social services and community resources)
 - g. Usual coping strategies
5. Medication use and compliance
 - a. Current prescribed medications: scheduled and as needed
 - b. Over-the-counter medications
 - c. Herbs
 - d. Vitamins

- e. Other (alternative drugs)
- f. Street drugs
- 6. Culture, language, and religion
 - a. Preferred language for receiving medical information
 - b. Need for translator
 - c. Cultural and/or religious practices that may influence care
- 7. Understanding of disease and anticipated treatment

B. Clinical Assessment

- 1. Overview
 - a. The patient is assessed before each treatment
 - b. Focused assessments are related to systems potentially affected by each agent in the treatment protocol
- 2. Cardiovascular
 - a. Blood pressure abnormalities
 - b. Apical and radial pulse; heart sounds and irregularities
 - c. Chest pain, diaphoresis, and palpitations
- 3. GI
 - a. Constipation
 - b. Diarrhea
 - c. Jaundice
 - d. Mucositis
 - e. Nausea
 - f. Taste alterations
 - g. Vomiting
 - h. Weight loss
- 4. Genitourinary
 - a. Urine color and amount
 - b. Dysuria, frequency, and pain
- 5. Integumentary
 - a. Alopecia
 - b. Cellulitis
 - c. Desquamation
 - d. Erythema
 - e. Facial flushing
 - f. Hyperpigmentation
 - g. Nail ridges
 - h. Pain
 - i. Phlebitis
 - j. Pruritus
 - k. Radiosensitization
 - l. Rash
- 6. Neurologic
 - a. Alterations in sensorium
 - b. Ataxia
 - c. Hearing loss
 - d. Paresthesia: numbness, tingling in fingers and toes
 - e. Tinnitus
 - f. Concentration and memory deficits
 - g. Fatigue

7. Respiratory
 - a. Breath sounds
 - b. Respirations
 - c. Edema
 - d. Pulse oximetry
 - e. Cough: dry or productive
 - f. Dyspnea
8. Hepatic
 - a. Pain
 - b. Jaundice
 - c. Ascites
9. Pain
 - a. Location
 - b. Severity (pain scale)
 - c. Precipitating factors
 - d. Relieving factors

C. Evaluation of Diagnostic Findings Prior to Each Treatment

1. Complete blood count (CBC) with differential; most chemotherapeutic agents cause myelosuppression
 - a. White blood count (WBC)
 - 1) Absolute neutrophil count (ANC) is the basis for knowing a patient's risk for infection
 - 2) Normal neutrophil count ranges from 3,000 to 7,000 cells/mm³
 - 3) To calculate ANC: $\text{WBC} \times (\% \text{ polys [segs]} + \% \text{ bands})$
Example: $\text{WBC} = 1,200$; $\text{segs} = 0.35\%$; $\text{bands} = 0.05\%$
 $1,200 \times 0.4 = 480$
 - 4) Neutropenia = $\text{ANC} < 1,500 \text{ cells/mm}^3$; $\text{ANC} < 500$ considered severe; high risk for infection
 - 5) Treatment usually held if neutropenia exists
 - b. Platelet count
 - 1) Normal is 150,000 to 400,000 cells/mm³
 - 2) Low platelet count increases the risk for bleeding
 - 3) Treatment may be held or dose decreased if thrombocytopenia present
 - c. Red blood cell (RBC) count
 - 1) Normal RBC: $4.0 \text{ to } 6.2 \times 10^{12}/\text{L}$ for adults
 - 2) Normal hemoglobin: 13.6 to 18 g/dL for males; 12 to 16 g/dL for females
 - 3) Normal hematocrit: 37% to 51% for males; 35% to 47% for females
 - 4) A blood transfusion and/or erythropoietin may be given for severe anemia
2. Blood urea nitrogen (BUN) and creatinine
 - a. To evaluate the renal function
 - b. An elevated creatinine may require a change in therapy or a dose reduction
 - c. The goal is to prevent renal failure from renal toxic agents
3. Liver function studies
 - a. May help to determine diagnosis
 - b. Used to monitor treatment
4. Tumor markers
 - a. Baseline obtained
 - b. Evaluated during treatment to monitor the response to treatment

- c. Monitored at the completion of the treatment and at follow-up visits to determine reoccurrence or progression of disease
- 5. Pulmonary function study
 - a. Baseline obtained for agents potentially causing pulmonary toxicities
 - b. Ordered periodically to monitor treatment with these agents
- 6. Cardiac evaluation
 - a. Baseline obtained prior to administration of agents with potential to cause cardiac abnormalities
 - b. Obtained periodically to monitor the effects of treatment

D. Understanding the Disease and Goals of Treatment

- 1. Type of cancer
 - a. Solid tumor (e.g., lung cancer)
 - b. Hematologic cancer (e.g., lymphoma)
 - c. Stage of disease
 - 1) Reported in pathology report
 - 2) Determined by staging system
 - 3) Most common is TNM staging system
 - a) T = size of the tumor
 - b) N = lymph node involvement
 - c) M = metastasis
- 2. Goals of the treatment
 - a. Cure: disease-free; a complete response that lasts 5 years or more
 - b. Control: increased survival or prevention of metastatic disease
 - c. Palliation: reduced severity or alleviation of symptoms with or without reduction in tumor burden and a goal to provide comfort

E. Evaluation of Treatment Orders

- 1. Treatment is determined by the oncologist based on tumor type, stage, patient's performance status, and number of times patient previously treated
- 2. Protocol prescribed
 - a. Single-agent chemotherapy: one agent used
 - b. Combination chemotherapy
 - 1) Most commonly used
 - 2) More than one agent is used to increase the response
 - 3) Provides multiple mechanisms of action with synergistic activity
 - 4) Helps to prevent drug resistance
 - c. Dose calculations
 - 1) Pediatric doses are usually calculated by weight (kg)
 - 2) Most agents' doses are calculated by body surface area (BSA)
 - a) Require patient's measured height and weight
 - b) Several formulas and methods of calculation; follow institution policy
 - c) Most common formula is the Mosteller Equation:

$$\frac{\sqrt{\text{height in cm} \times \text{weight in kg}}}{3,600}$$
 - d) Reputable online BSA calculators or those found in an electronic medical record may be used instead of the formula
 - e) Dose is calculated as $\text{BSA} \times \text{dose expressed in m}^2$ (example: drug prescribed is doxorubicin 50 mg/m²; patient's BSA is 1.8; $50 \times 1.8 = 90$ mg of doxorubicin)

- 3) Area under the curve (AUC)
 - a) Used to calculate Carboplatin dose
 - b) Does not use BSA
 - c) Creatinine clearance must first be calculated
 - d) Dosing calculations include the patient's age, sex, weight, glomerular filtration rate, and creatinine clearance
 - e) Computer-based programs can be used for calculations
- d. Check orders for appropriate premedications given before agent(s) based on anticipated side effects of the therapy such as antiemetics, antihistamines, steroids, electrolytes, vitamins, and fluids
- e. Ensure licensed independent practitioner's (LIP's) orders include, but not limited to the following, post-treatment medications such as antiemetics, steroids, electrolytes, and antipyretics
- f. Identify the antineoplastic drugs that are irritants and vesicants before administration
 - 1) Overview
 - a) Agents are classified by the degree of irritation or tissue damage that is caused if infiltrated
 - b) Includes the categories of vesicants and irritants; agents not listed in either category are presumed to be nondamaging if infiltrated
 - c) Careful vein and device selection with frequent assessment during administration is necessary
 - 2) Vesicants
 - a) Toxic to soft tissue, inducing tissue necrosis if extravasation occurs
 - b) Interventions
 - Central vascular access device (CVAD) is recommended for administration of vesicants
 - Avoid using peripheral VAD that is more than 24 hours old
 - Monitor the infusion site during administration of vesicant drugs; check patency every 2 to 5 mL with IV push vesicant administration
 - If there is an actual or suspected extravasation, stop administration of drug and fluids and initiate extravasation protocol
 - Instruct patient regarding appropriate follow-up for evaluation of tissue damage and possible referral to a plastic surgeon
 - 3) Irritants
 - a) Burning, pain, edema, or erythema may occur without soft tissue necrosis

F. Vascular Access Considerations

1. Peripheral access appropriate for short-term treatment, nonvesicant agents, in patients with sufficient useable veins
2. Central vascular access appropriate for long-term treatments, vesicant agents, in patients with few useable veins and in those with contraindications for access such as arm affected by cerebral vascular accident (CVA), side of a mastectomy with lymph node dissection, or arm with dialysis fistula

G. Patient and Caregiver Education

1. Determine the preferred language for education; elicit the assistance of a translator as needed
2. Determine the preferred learning style

3. Determine from the patient the information desired
4. Provide verbal and written information
5. Involve a relative, friend, or caregiver if possible
6. Review the plan of care
 - a. Agents to be used
 - b. Route(s) of administration
 - c. Number of cycles
 - d. Frequency of treatment
 - e. Tests/procedures required before and during the treatment to monitor the response
7. Provide information on the following:
 - a. Name of agents—generic and brand names
 - b. Potential side effects
 - c. Managing symptoms
 - 1) Prescribed medications and use
 - 2) Self-care strategies
 - a) Infection and bleeding precautions
 - b) Mouth care
 - c) Avoid exposure to sun
 - d) Avoid aspirin and aspirin-containing products
 - e) Adequate fluid intake; nutritional support
 - f) Energy conservation strategies
 - g) Home management of antiemetic and antidiarrheal medications
 - h) When to call the LIP
 - i) Body fluid precautions
 - j) Precautions related to sexual intercourse and contraception
 - d. Available support services such as dietician, social services, physical therapy, psychology services, and community resources
 - e. Follow-up appointment and laboratory test monitoring
 - 1) Routine laboratory tests before treatments
 - 2) Laboratory tests, radiological studies, and other tests required to determine the response to treatment, measure degree of toxicity, or to restage disease
8. Patient rights: treatment refusal
9. Follow-up care
10. When and how to contact the healthcare team



VI. Administration Considerations

A. Personnel

1. An RN administering chemotherapy must have the required knowledge, skill, and competency per organizational policy
2. Policies and procedures are followed for handling, administration, and disposal by appropriate personnel

B. Vascular Access

1. Peripheral
 - a. Nonvesicant medications for short duration

- b. May be used for intravenous (IV) push administration of vesicant medications
- 2. Short-term CVADs
 - a. Short-term therapy, usually 30 to 60 days
 - b. Nontunneled short-term CVAD (e.g., subclavian or jugular catheter)
 - c. Peripherally inserted central catheter
- 3. Long-term CVADs
 - a. Used when extended therapy is expected
 - b. Patients with limited venous access, anticipated long-term treatment, or those receiving vesicants or irritating chemotherapy
 - c. Tunneled CVAD
 - d. Implanted vascular access port
 - 1) Note that there is risk of potential needle dislodgement with port-based infusions, which increases the risk of infiltration/extravasation

C. Routes of Administration

- 1. Systemic
 - a. IV, most common
 - b. Subcutaneous
 - c. Intramuscular
 - d. Oral
- 2. Regional
 - a. Intra-arterial
 - b. Intraventricular or intrathecal
 - c. Intraperitoneal
 - d. Intrapleural
 - e. Intravesicular
 - f. Topical

D. Methods of IV Administration

- 1. Direct IV push—agent given directly into the catheter without a diluent or IV fluids
- 2. IV push through free-flowing IV—agent given through the injection port on the administration set closest to the patient while IV fluids are flowing freely to dilute the agent during administration
- 3. Continuous infusion—agent given over several hours to days
- 4. Intermittent infusion—a short-term infusion (e.g., 30 to 60 minutes)

E. Compounding

- 1. Limit to qualified personnel who have demonstrated competency to compound drugs under a biologic safety cabinet
- 2. Specific equipment
 - a. Class II biologic vertical laminar airflow safety cabinet
 - b. Syringes with luer-lock connections
 - c. Vented vials

F. Specific Considerations for Administration

1. LIP orders
 - a. Verify medication, dose, route, and patient identification
 - b. Double-check orders and medication with another nurse or a pharmacist
2. Recommendations when administering chemotherapy agents
 - a. Use safe and protective techniques to minimize the potential risk
 - b. Follow the Occupational Safety and Health Administration (OSHA) guidelines for handling chemotherapy
 - 1) Wear disposable, powder-free nitrile gloves
 - 2) Change gloves at regular intervals and when integrity is compromised
 - 3) Wear closed-front gowns with long sleeves and fitted cuffs; fabric of low permeability material
3. Maintain aseptic technique
4. Assure patency of vascular access device
 - a. Administer 0.9% sodium chloride before antineoplastic given and observe for signs of infiltration
 - b. Instruct patient to report any burning or pain during infusion
 - c. Assess patency by periodic check of blood return

G. Immediate Complications

1. Hypersensitivity reactions
 - a. An allergic reaction mediated by the immune system
 - b. Reaction usually occurs within minutes of initiating the infusion
 - c. Follow hypersensitivity protocol
2. Infusion reactions
 - a. A reaction due to cytokine release from targeted cells and other immune cells
 - b. Associated with the administration of monoclonal antibodies (see Part II)
3. Extravasation
 - a. Infiltration of a vesicant
 - b. Tissue damage and necrosis usually develops
 - c. Symptoms include pain at the catheter insertion site, redness, swelling, burning, and absence of blood return
 - d. Follow extravasation protocol
4. Vein irritation
 - a. Inflammation of a peripheral vein by an irritant agent
 - b. Produces redness or discoloration of vein, aching, and tight feeling along the vein
 - c. Blood return present
5. Vein flare
 - a. Course of vein becomes reddened
 - b. Blood return is present
 - c. Subsides when the agent is stopped
 - d. Hydrocortisone is given IV to diminish the reaction



VII. Side Effects/Toxicities

A. Neutropenia (hematologic)

1. Decreased WBCs with decreased neutrophils, predisposing patient to risk of infection; ANC < 1,500
2. Interventions
 - a. Assess patient for signs of infection: fever ($>38^{\circ}\text{C}$ or $>100.4^{\circ}\text{F}$), chills, sore throat, cough, dyspnea, frequency or urgency with voiding, edema, or purulent drainage at sites of skin breaks
 - b. Monitor WBC and ANC
 - c. After chemotherapy, the point at which the lowest blood cell count is reached is called the nadir
 - 1) Usually about 7 to 10 days after chemotherapy administration
 - 2) WBC and platelet counts are usually the first to drop
 - d. Notify the LIP of WBC < 4,000/mm³ or ANC < 2,000/mm³
 - e. Obtain cultures and chest X-ray, administer antibiotics as ordered
 - f. Administer colony-stimulating factors (G-CSF or GM-CSF) to prevent neutropenia
 - g. Teach patient and visitors regarding hand hygiene
 - h. Remove plants and flowers from patient's immediate environment
 - i. Use automatic ice dispensers versus ice bins
 - j. Instruct patient to avoid contact with animal contaminants such as droppings, feces, urine, saliva, and litter box

B. Thrombocytopenia (hematologic)

1. Decreased platelet count; platelets < 100,000 mm³
2. Interventions
 - a. Assess patient for bleeding in gums and nose, presence of blood in urine and feces, easy bruising of skin, headaches, hypotension, tachycardia, or enlarged spleen/liver
 - b. Monitor platelet count and notify LIP if < 50,000/mm³
 - c. Instruct patient regarding bleeding precautions, including the use of electric razors and soft toothbrush and avoiding nose blowing
 - d. Caution against activities that may cause abrasions, cuts, or trauma
 - e. Apply pressure to the sites of bleeding and notify the LIP if bleeding persists

C. Anemia (hematologic)

1. Reduced number of RBCs with a decrease in the blood's oxygen-carrying capacity
 - a. Normal hemoglobin: 13.6 to 18 g/dL for males; 12 to 16 g/dL for females
 - b. Normal hematocrit: 37% to 51% for males; 35% to 47% for females
2. Interventions
 - a. Assess patient for fatigue, dyspnea, pallor, tinnitus, tachycardia, palpitations, fainting, headaches, and irritability

- b. Monitor hemoglobin and hematocrit and notify the LIP of abnormal results
- c. Administer RBCs or oxygen as ordered; or erythropoietin (Epogen) as ordered
- d. Instruct the patient regarding the need for rest and planning of activities to maximize energy

D. Nausea and Vomiting (gastrointestinal)

1. Increased risk of dehydration and compromised nutritional status
2. Interventions
 - a. Monitor oral intake
 - b. Provide adequate antiemetic therapy based on emetogenic properties of the antineoplastic therapy
 - c. Provide information on nutrition and nutritional supplements
 - d. Administer antiemetics
 - 1) Dexamethasone (Decadron)
 - a) Administer a 10- to 20-mg single dose 30 minutes prior to chemotherapy
 - b) Give in combination with other medications
 - 2) Lorazepam (Ativan)
 - a) Administer 1 to 3 mg by mouth or 0.5 to 2.5 mg IV (IV push or through injection port of IV administration set over 1 minute)
 - b) Give in combination with other medications
 - 3) Metoclopramide (Reglan)
 - a) Administer 2 to 3 mg/kg IV by infusion over at least 15 minutes, 30 minutes prior to chemotherapy
 - b) Give in combination with other medications
 - 4) Ondansetron (Zofran)
 - a) Administer a single dose of 8 to 32 mg IV over 15 minutes, 30 minutes prior to chemotherapy
 - 5) Granisetron (Kytril)
 - a) Administer a 0.01-mg/kg IV dose over 5 minutes, 30 minutes prior to chemotherapy
 - 6) Palonosetron (Aloxi)
 - a) Administer a single dose of 0.25 mg IV push over 30 seconds, 30 minutes prior to chemotherapy
 - 7) Aprepitant and Fosaprepitant (Emend)
 - a) Aprepitant is given orally 30 minutes prior to chemotherapy
 - b) Fosaprepitant is a single 150 mg IV dose given 30 minutes prior to chemotherapy
 - 8) Prochlorperazine (Compazine)
 - a) Given by mouth, IV, per rectum, as needed for nausea

E. Anorexia (gastrointestinal)

1. Increased risk of compromised nutritional status
2. Interventions
 - a. Monitor patient's weight
 - b. Monitor laboratory values (serum albumin, nitrogen balance, glucose, transferrin, and electrolytes)

- c. Instruct patient to eat foods high in protein and calories, use nutritional supplements, and try eating smaller, more frequent meals
- d. Stress the importance of oral care and identify the methods to stimulate taste buds and appetite
- e. Consider appetite stimulants (e.g., Megace) or parenteral nutrition if gastrointestinal function is altered

F. Constipation (gastrointestinal)

1. Decreased bowel elimination
2. Interventions
 - a. Assess bowel elimination patterns, diet and fluid intake, and medication use
 - b. Assess patient for dry skin and mucous membranes, for poor skin turgor, and for bowel sounds
 - c. Instruct patient regarding increasing fluid intake, eating high-fiber and high-bulk foods, and the appropriate use of laxatives or stool softeners, as indicated

G. Diarrhea (gastrointestinal)

1. Increased risk of fluid and electrolyte disturbance and dehydration
2. Interventions
 - a. Assess the frequency and character of stools
 - b. Monitor patient's weight
 - c. Monitor serum electrolytes
 - d. Administer antidiarrheal agents as ordered
 - e. Instruct patient regarding low residue, high-protein diet and to eat small meals with high fluid intake at frequent intervals
 - f. Advise avoiding caffeine and tobacco

H. Alopecia (integumentary)

1. Increased risk of depression from poor self-image
2. Interventions
 - a. Instruct patient regarding the use of wigs or turbans prior to hair loss
 - b. Provide psychological reassurance and encourage the expression of feelings
 - c. For mild-to-moderate hair loss, instruct patient regarding the use of mild shampoo, gentle brushing, and avoiding hair dryers, curling irons, and curlers

I. Mucositis (integumentary)

1. Increased risk of compromised nutritional status, sepsis, and pain
2. Interventions
 - a. Assess oral mucosa for bleeding, erythema, ulceration, and white or yellow plaques
 - b. Instruct patient about good oral care with saline mouth rinse and after-meal teeth cleaning with soft toothbrush or soft swab
 - c. Avoid commercial mouthwashes, elective dental work, alcohol, and tobacco
 - d. Encourage soft, bland, and medium temperature foods and fluids

- e. Instruct patient regarding the use of topical anesthetics and swish-and-swallow medications
- f. For severe mucositis, provide adequate analgesics for pain

J. Cardiotoxicity

- 1. Risk of myocardial damage, decreased cardiac output, and tissue perfusion leading to congestive heart failure (CHF), cardiac arrhythmias, or cardiomyopathy
- 2. Interventions
 - a. Assess patient for ankle edema, cough, cyanosis, dyspnea, decreased peripheral pulses, jugular vein distention, rales, and tachycardia
 - b. Monitor ECG, cardiac enzymes and electrolytes, and vital signs with apical pulse
 - c. Notify the LIP of irregularities and administer medication as ordered

K. Neurotoxicity

- 1. May be central or peripheral
- 2. Interventions
 - a. Assess patient for paresthesias, deep tendon reflexes, jaw pain, bowel sounds, numbness in extremities, inability to walk on heels, confusion, or slurred speech
 - b. Instruct patient to take adequate fluids and use stool softeners
 - c. Contact physical therapy, if needed, to assist with mobility, exercise, and physical aids

L. Ototoxicity

- 1. Risk of decreased or lost hearing; hearing loss is more commonly seen in pediatric patients
- 2. Interventions
 - a. Assess patient for changes in hearing, sense of coordination, and tinnitus
 - b. Implement strategies to provide communication in the event of any hearing loss

M. Nephrotoxicity

- 1. Risk of impaired renal function
- 2. Interventions
 - a. Adequate hydration using IV fluids before and after drug administration; encourage oral fluid intake
 - b. Assess for any difficulty, frequency, or urgency with voiding
 - c. Monitor BUN, serum creatinine, creatinine clearance, urinalysis, and uric acid
 - d. Notify the LIP of any abnormal results
 - e. Encourage patient to empty bladder every 4 hours, especially at night
 - f. Monitor urine pH if patient is receiving high-dose methotrexate

N. Pulmonary Toxicity

- 1. Risk of decreased pulmonary function
- 2. Interventions
 - a. Assess breath sounds; observe for dry, hacking cough, and signs of dyspnea
 - b. Notify the LIP of abnormal findings and administer oxygen, as ordered

O. Altered Sexuality/Reproductive Function

1. Impaired sexuality, decreased quality of life, and infertility
2. Interventions
 - a. Assess sexual functioning and refer for consultation, as needed
 - b. Discuss possible reproductive dysfunction and fertility options before the start of chemotherapy (e.g. sperm banking)
 - c. Discuss birth control methods to use while receiving antineoplastic therapy

P. Ocular Toxicity

1. Visual impairment, infection, inflammation, and irritation
2. Interventions
 - a. Monitor for ocular symptoms (e.g. erythema, edema, exudate, ptosis, photophobia, pain, dryness, excessive tearing, and changes in acuity)
 - b. Refer patient to ophthalmologist yearly and when signs of toxicity are noted
 - c. Eye drops or lubricants may be prescribed to decrease inflammation, dryness, or infection



VIII. Pharmacologic Categories

A. Alkylating Agents

1. Drug specificity: cell cycle-nonspecific
2. Action: interferes with DNA replication
3. Toxicity: hematologic, GI, renal, and reproductive

B. Antitumor Antibiotics

1. Drug specificity: cell cycle-nonspecific
2. Action: interferes with RNA synthesis, inhibits DNA synthesis by binding or reacting to DNA
3. Toxicity: hematologic, GI, reproductive, and cardiac (cumulative doses)

C. Antimetabolites

1. Drug specificity: cell cycle-specific: S phase
2. Action: inhibits DNA synthesis and protein synthesis
3. Toxicity: hematologic and GI

D. Nitrosoureas

1. Drug specificity: cell cycle-nonspecific
2. Action: interferes with DNA replication and repair
3. Toxicity: hematologic and GI

E. Vinca Alkaloids

1. Drug specificity: cell cycle-specific: G₂ and M phases
2. Action: blocks DNA production and prevents cell division
3. Toxicity: neurologic

F. Miscellaneous

1. Drug specificity, action, and toxicity vary



IX. Antineoplastic Agents

Dosing: unless otherwise specified, the drug may be used as a single agent or in combination with other agents; the dose is individualized, based upon tolerance of and response to agent and in accordance with published protocols or literature

A. Arsenic Trioxide (Trisonox)

1. Classification
 - a. Pharmacologic category: miscellaneous
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: nonvesicant
2. Indications: acute promyelocytic leukemia (APL), myelodysplastic syndrome, and multiple myeloma
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, nausea, vomiting, diarrhea, constipation, GI hemorrhage, arthralgias, bone pain, dizziness, headache, insomnia, paresthesias, pruritus, hyperpigmentation, urticaria, dyspnea, APL differentiation syndrome (fever, weight gain, dyspnea, pulmonary, or pleural infiltrates), cardiac toxicity, hypersensitivity, renal toxicity, and hepatic toxicity
5. Considerations
 - a. A human carcinogen
 - b. ECG should be done prior to treatment

B. Asparaginase (Elspar)

1. Classification
 - a. Pharmacologic category: miscellaneous
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indications: acute lymphocytic leukemia
3. Method of administration: intramuscular, IV push, and continuous infusion
4. Side effects/toxicities: nausea, vomiting, hypersensitivity reactions including anaphylaxis, myelosuppression, hepatic dysfunction, hyperglycemia, hyperlipidemia, onset of pancreatitis in children, lethargy, and somnolence
5. Considerations
 - a. Perform intradermal test dose before initial drug administration
 - b. Have emergency supportive care available in the event of an anaphylactic response

C. Azacytidine (Vidaza)

1. Classification
 - a. Pharmacologic category: antimetabolite
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: nonvesicant
2. Indications: myelodysplasia

3. Method of administration: intermittent infusion; subcutaneous
4. Side effects/toxicities: myelosuppression, nausea, vomiting, anorexia, stomatitis, constipation, diarrhea, fever, fatigue, arthralgias, and injection site irritation
5. Considerations
 - a. Dose modifications based on myelosuppression, renal function, and electrolytes
 - b. For subcutaneous administration, divide doses greater than 4 mL into two syringes
 - c. Must be given within 1 hour of reconstitution

D. Bendamustine (Treanda)

1. Classification
 - a. Pharmacologic category: alkylating agent
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: nonvesicant
2. Indications: chronic lymphocytic leukemia (CLL), indolent B-cell non-Hodgkin's lymphoma
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, infusion reaction, anaphylaxis, tumor lysis syndrome, nausea, vomiting, diarrhea, and rash
5. Considerations
 - a. Dose reductions for myelosuppression
 - b. Severe skin reactions, severe infusion reactions, or anaphylaxis require discontinuation of the drug

E. Bleomycin (Blenoxane)

1. Classification
 - a. Pharmacologic category: antitumor antibiotic
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: irritant
2. Indications: Hodgkin's disease; non-Hodgkin's lymphoma (NHL); squamous cell carcinoma of the head and neck; cancer of penis, cervix, vulva, and testes
3. Dose: 10 to 20 units/m² weekly or twice weekly
4. Method of administration: IV push, continuous infusion, subcutaneous injection, intramuscular, and intrapleural
5. Side effects/toxicities: fever, chills, stomatitis, nausea, vomiting, hyperpigmentation, alopecia, hypersensitivity reactions, erythema, rash, photosensitivity, renal toxicity, liver toxicity, pulmonary fibrosis, and pneumonitis (dry cough and dyspnea)
6. Considerations
 - a. Administer test dose as recommended, especially in patients with lymphoma
 - b. Prepare for possible anaphylactic reaction
 - c. Pulmonary function studies should be done before each cycle
 - d. Lifetime cumulative dose should not exceed 400 units

F. Carboplatin (Paraplatin)

1. Classification
 - a. Pharmacologic category: alkylating agent
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: nonvesicant

2. Indications: cancer of the ovaries, testes, head and neck, cervix, lung, solid tumors (including brain), and in preparation for bone marrow transplant
3. The dose is calculated based on renal function using the AUC dosing calculation
4. Method of administration: intermittent or continuous infusion, IV bolus, and intraperitoneal
5. Side effects/toxicities: anemia, thrombocytopenia (dose-limiting), neutropenia, mild nausea and vomiting, paresthesias, stomatitis, nephrotoxicity, hepatic toxicity, and neurologic dysfunction
6. Considerations
 - a. Monitor CBC, platelets, and creatinine
 - b. May cause hypersensitivity reaction, usually after 5 to 6 cycles

G. Carmustine (BCNU)

1. Classification
 - a. Pharmacologic category: nitrosourea
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: irritant
2. Indications: Hodgkin's disease, NHL, central nervous system (CNS) tumors, melanoma, myeloma, in preparation for bone marrow transplant
3. Method of administration: intermittent or continuous infusion
4. Side effects/toxicities: delayed bone marrow suppression (nadir in 4 weeks), nausea, vomiting, renal toxicity, liver toxicity, pulmonary fibrosis, and ocular toxicity
5. Considerations
 - a. Thrombocytopenia is dose-limiting
 - b. Rapid IV infusion may cause burning along vein and skin to flush

H. Cisplatin (Platinol)

1. Classification
 - a. Pharmacologic category: alkylating agent
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: irritant; vesicant if concentrated
2. Indications: neuroblastoma; cancer of the testes, bladder, head and neck, ovary, prostate, or lung; Wilms' tumor; leukemia; multiple myeloma; and lymphoma
3. Method of administration: intermittent or continuous infusion
4. Side effects/toxicities: myelosuppression, severe nausea and vomiting, hyperuricemia, hypokalemia, hypomagnesia, ototoxicity, peripheral neuropathy, renal toxicity, and alopecia
5. Considerations
 - a. Ensure adequate hydration before and after administration of the medication to minimize impaired renal function; mannitol is used to achieve osmotic diuresis
 - b. Monitor BUN and creatinine
 - c. Very high risk for nausea and vomiting; ensure sufficient antiemetics are prescribed

I. Cyclophosphamide (Cytosan)

1. Classification
 - a. Pharmacologic category: alkylating agent

- b. Drug specificity: cell cycle-nonspecific
 - c. Category: nonvesicant
- 2. Indications: Ewing's sarcoma; Burkitt's tumor; Hodgkin's disease; NHL; mycosis fungoides; lymphocytic leukemia; CLL; myeloma; neuroblastoma; Wilms' tumor; cancer of the breast, lung, and ovary; in preparation for bone marrow transplant
- 3. Method of administration: IV push, continuous infusion
- 4. Side effects/toxicities: myelosuppression, nausea, vomiting, renal toxicity, alopecia, sterility, dermatitis, hemorrhagic cystitis, stomatitis, hepatic toxicity; high dose is associated with secondary malignancy, SIADH and cardiomyopathy
- 5. Considerations
 - a. Hydration is essential to reduce the potential for hemorrhagic cystitis
 - b. Have patient void frequently and empty the bladder to prevent hemorrhagic cystitis
 - c. Monitor renal status

J. Cytarabine (Cytosine Arabinoside, Cytosar-U)

- 1. Classification
 - a. Pharmacologic category: antimetabolite
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
- 2. Indications: acute myeloid leukemia (AML), acute lymphocytic leukemia, chronic myeloid leukemia (CML) in blast crisis, Hodgkin's disease, NHL, and CNS leukemia
- 3. Method of administration: IV push, intermittent or continuous infusion, intrathecal
- 4. Side effects/toxicities: nausea, vomiting, anorexia, mucositis, diarrhea, myelosuppression (related to dose), fever, malaise, myalgia, photophobia, pruritus, rash, alopecia, renal toxicity, hepatic toxicity, localized pain or thrombophlebitis at venipuncture site with high dose, cerebellar toxicity, and conjunctivitis
- 5. Considerations
 - a. Steroid eye drops used for conjunctivitis prophylactically
 - b. Risk for tumorlysis syndrome, ensure adequate hydration, and administer allopurinol as prescribed

K. Dacarbazine (DTIC)

- 1. Classification
 - a. Pharmacologic category: alkylating agent
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: irritant
- 2. Indications: melanoma, soft tissue sarcomas, Hodgkin's disease, and neuroblastoma
- 3. Method of administration: continuous or intermittent infusion; IV push
- 4. Side effects/toxicities: severe nausea and vomiting (as long as 12 hours), myelosuppression (nadir in 2 to 3 weeks or more), alopecia, rash, flu-like syndrome (occurs as long as 7 days after administration), hepatic toxicity, and photosensitivity

5. Considerations
 - a. To minimize pain and burning at the injection site and along the course of the vein: increase drug dilution, decrease infusion rate, and apply cool compress to venipuncture site and along vein
 - b. Instruct patients to avoid sun exposure or to use sun protection in sunlight while receiving this drug
 - c. Protect solution from light (change in the color of the solution from ivory to pink indicates decomposition)

L. Dactinomycin (Cosmegen)

1. Classification
 - a. Pharmacologic category: antitumor antibiotic
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: vesicant
2. Indications: Wilms' tumor, choriocarcinoma, testicular tumors, Ewing's sarcoma, and rhabdomyosarcoma
3. Method of administration: IV push, continuous infusion
4. Side effects/toxicities: myelosuppression (dose-limiting), nausea, vomiting, fever, alopecia, stomatitis, fatigue, mental depression, flu-like symptoms, radiation recall, diarrhea, hepatic toxicity, and renal toxicity
5. Considerations
 - a. Should be given through the side arm of a free-flowing IV

M. Daunorubicin Hydrochloride (Cerubidine)

1. Classification
 - a. Pharmacologic category: antitumor antibiotic
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: vesicant
2. Indications: acute nonlymphocytic leukemia, NHL, and acute lymphocytic leukemia in children
3. Method of administration: IV push
4. Side effects/toxicities: myelosuppression, back pain, flushing, chest tightness, mild nausea, vomiting, mild alopecia, diarrhea, fatigue, radiation recall, hyperuricemia, and cardiotoxicity
5. Considerations
 - a. Obtain baseline MUGA scan for cardiac ejection fraction
 - b. Total cumulative dose should not exceed 550 mg/m²
 - c. Instruct patients to expect reddish-colored urine after receiving this medication

N. Decitabine (Dacogen)

1. Classification
 - a. Pharmacologic category: antimetabolite
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indications: myelodysplasia
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, fatigue, fever, cough, nausea, constipation, diarrhea, and hyperglycemia

5. Considerations
 - a. Use within 15 minutes of reconstitution

O. Docetaxel (Taxotere)

1. Classification
 - a. Pharmacologic category: taxanes
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: irritant
2. Indications: breast cancer, nonsmall-cell lung cancer (NSCLC), head and neck cancer, and metastatic ovarian cancer
3. Method of administration: continuous infusion
4. Side effects/toxicities: myelosuppression, hypersensitivity reaction, fatigue, fluid retention, alopecia, skin/nail changes, stomatitis, nausea, vomiting, diarrhea, peripheral neuropathy (dose-limiting), and hyperlacrimation
5. Considerations
 - a. Dexamethasone given 3 days starting with the day before the start of docetaxel
 - b. Use non-PVC containers and administration sets

P. Doxorubicin Hydrochloride (Adriamycin)

1. Classification
 - a. Pharmacologic category: antitumor antibiotic
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: vesicant
2. Indications: AML; acute lymphocytic leukemia; Hodgkin's disease; lymphoma; cancer of the breast, thyroid, ovary, prostate, stomach, cervix, liver, or head and neck; small cell carcinoma of the lung; and multiple myeloma
3. Method of administration: IV push and continuous infusion
4. Side effects/toxicities: myelosuppression, cardiotoxicity, alopecia, mucositis, nausea, vomiting, fever, hyperpigmentation of nail bed, and radiation recall
5. Considerations
 - a. Obtain baseline MUGA scan for cardiac ejection fraction
 - b. Instruct patients to expect reddish-colored urine after the first few voidings
 - c. Total cumulative lifetime dose should not exceed 550 mg/m² (450 mg/m² if patient had prior chest irradiation/concomitant cyclophosphamide therapy)
 - d. Dexrazoxane (Zinecard) may be used as a cardioprotectant in pediatric patients or when the cumulative dose reaches 300 mg/m²
 - e. May cause flare reaction during administration

Q. Doxorubicin Liposome Injection (Doxil)

1. Classification
 - a. Pharmacologic category: antitumor antibiotic
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: irritant
2. Indications: Kaposi's sarcoma and ovarian cancer
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, cardiac changes, hypersensitivity reaction, hand-foot syndrome (dose-limiting), nausea, vomiting, diarrhea,

stomatitis, alopecia, flushing, rash, radiation recall, myocardial toxicity, fever, and fatigue

5. Considerations
 - a. Use 5% dextrose in water only; the agent is not compatible with 0.9% sodium chloride solutions
 - b. Instruct patient to expect reddish-colored urine after the first few voidings
 - c. Do not use in-line filters
 - d. Total cumulative dose should not exceed 550 mg/m²
 - e. Initiate infusion at 1 mg/minute to decrease the risk of infusion reaction

R. Epirubicin (Ellence)

1. Classification
 - a. Pharmacologic category: antitumor antibiotic
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: vesicant
2. Indication: axillary node positive breast cancer
3. Method of administration: IV push
4. Side effects/toxicities: myelosuppression, cardiac toxicity, nausea, vomiting, stomatitis, alopecia, radiation recall, flushing, skin and nail hyperpigmentation
5. Considerations
 - a. Administer through injection port of free-flowing IV
 - b. Urine will be pink-red for 1 to 2 days after administration

S. Etoposide (VP-16, VePesid)

1. Classification
 - a. Pharmacologic category: epipodophyllotoxin
 - b. Drug specificity: cell cycle-specific
 - c. Category: irritant
2. Indications: acute lymphocytic leukemia, small cell carcinoma of the lung, Hodgkin's disease, cancers of the breast and testes, NHL, and multiple myeloma
3. Method of administration: intermittent or continuous infusion
4. Side effects/toxicities: myelosuppression, nausea, vomiting, alopecia, anorexia, orthostatic hypotension (if administered in <15 minutes), allergic reaction, radiation recall, rare myocardial infarction, peripheral neuropathy, and secondary malignancy
5. Considerations
 - a. Monitor for hypotension
 - b. Monitor for drug crystallization during infusion

T. Fludarabine (Fludara)

1. Classification
 - a. Pharmacologic category: antimetabolite
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indications: CLL, low-grade lymphoma, in preparation for bone marrow transplant
3. Method of administration: IV infusion over 30 minutes

4. Side effects/toxicities: myelosuppression, fatigue, nausea, vomiting, diarrhea, rash, interstitial pneumonitis, and neurotoxicity
5. Considerations
 - a. For patients requiring transfusions, use irradiated blood products to prevent graft-versus-host disease

U. Fluorouracil (5-FU)

1. Classification
 - a. Pharmacologic category: antimetabolite
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indications: cancers of the breast, ovary, GI tract, liver, and pancreas
3. Method of administration: IV push, intermittent or continuous infusion, hepatic infusion
4. Side effects/toxicities: myelosuppression, stomatitis, nausea, vomiting, diarrhea, alopecia, skin manifestations (darkened veins), photosensitivity, cerebellar ataxia, and photophobia
5. Considerations
 - a. Instruct patient to avoid sun exposure and to use sun protection when in sunlight
 - b. Monitor INR; anticoagulant effect of warfarin may be increased

V. Gemcitabine (Gemzar)

1. Classification
 - a. Pharmacologic category: antimetabolite
 - b. Drug specificity: cell cycle-specific
 - c. Category: irritant
2. Indications: cancers of the pancreas, breast, ovary, and lung
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, nausea, vomiting, fever, rash, water retention, alopecia, flu-like symptoms, and increased liver function tests
5. Considerations
 - a. To promote renal drug clearance, administer gemcitabine before cisplatin; administer gemcitabine after paclitaxel

W. Hydroxyurea (Hydrea)

1. Classification
 - a. Pharmacologic category: miscellaneous/antimetabolite
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indications: CML, sickle cell anemia, radiosensitizer (makes tumor cells more sensitive to radiation therapy)
3. Method of administration: intermittent infusion, oral
4. Side effects/toxicities: myelosuppression, nausea, vomiting, diarrhea, stomatitis, hepatic dysfunction, hyperkalemia, hyperphosphatemia, hypocalcemia, hyperuricemia, drowsiness, and hallucinations
5. Considerations
 - a. Crosses the blood–brain barrier
 - b. May cause tumor lysis syndrome—administer allopurinol

X. Ifosfamide (Ifex)

1. Classification
 - a. Pharmacologic category: alkylating agent
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indications: cancers of the lung, testes, breast, and ovary; sarcoma; and NHL
3. Method of administration: continuous or intermittent infusion
4. Side effects/toxicities: hemorrhagic cystitis, myelosuppression, nausea, vomiting, alopecia, fatigue, hyperpigmentation, confusion, and neurotoxicity
5. Considerations
 - a. Ensure patient receives at least 2 L of fluid, intravenously or orally, to prevent bladder toxicity
 - b. Always give mesna (Mesnex) in conjunction with ifosfamide as a uroprotective agent
 - c. Monitor BUN and serum creatinine

Y. Irinotecan (Camptosar)

1. Classification
 - a. Pharmacologic category: miscellaneous
 - b. Drug specificity: cell cycle-specific
 - c. Category: irritant
2. Indications: carcinoma of the colon and rectum
3. Method of administration: continuous or intermittent infusion
4. Side effects/toxicities: diarrhea (dose-limiting), nausea, vomiting, alopecia, myelosuppression, dehydration, dyspnea, and fever
5. Considerations
 - a. Diarrhea may be early or late; early onset (within 24 hours) may be prevented with IV atropine
 - b. Atropine is also given for other cholinergic effects such as tearing, salivation, disturbances with vision, piloerection, and bradycardia
 - c. Loperamide is used for late onset diarrhea
 - d. Teach patients the methods to prevent/treat diarrhea

Z. Ixabepilone (Ixempra)

1. Classification
 - a. Pharmacologic category: epothilone B analog
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indication: metastatic or locally advanced breast cancer
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, hypersensitivity reactions, sensory and motor neuropathies, alopecia, nail changes, arthralgias, nausea, vomiting, and diarrhea
5. Considerations
 - a. Administer using DEHP-free tubing with DEHP-free 0.2- to 1.2-micron filter
 - b. Premedicate with diphenhydramine and an H₂ antagonist (e.g., ranitidine, cimetidine, or famotidine) to prevent hypersensitivity reaction

AA. Leucovorin Calcium (Citraject)

1. Classification: antineoplastic adjunct
2. Indications: to potentiate the action of fluorouracil therapy; prevents the toxicity of high-dose methotrexate
3. Method of administration: oral and intermittent infusion
4. Side effects/toxicity: hypersensitivity reactions
5. Considerations: maximum rate of infusion is 160 mL/h

BB. Mechlorethamine Hydrochloride (Mustargen)

1. Classification
 - a. Pharmacologic category: alkylating agent
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: vesicant
2. Indications: Hodgkin's disease, CLL, and chronic myelogenous leukemia
3. Method of administration: IV push and intracavitary
4. Side effects/toxicities: severe nausea and vomiting, myelosuppression, alopecia, local cellulitis, chills, fever, and sterility
5. Considerations
 - a. Has a short period of stability (15 minutes)
 - b. Administer IV push via injection port of a free-flowing IV

CC. Mesna (Mesnex)

1. Classification: antineoplastic adjunct
2. Indications: concurrent therapy with ifosfamide and high-dose cyclophosphamide to prevent hemorrhagic cystitis
3. Method of administration: oral and intermittent infusion
4. Side effects/toxicities: nausea, vomiting, diarrhea, hypotension, headache, taste alterations, and abdominal pain
5. Considerations
 - a. May be compounded with cyclophosphamide and ifosfamide
 - b. With ifosfamide given at 60% of the total dose
 - c. With high-dose cyclophosphamide given at 40% of the total dose; given 15 minutes before, and 4 and 8 hours after administration of the agents

DD. Methotrexate (Mexate-AQ)

1. Classification
 - a. Pharmacologic category: antimetabolite
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indications: cancers of the breast, cervix, lung, and head and neck; osteogenic sarcoma; Hodgkin's disease; lymphoma; leukemia; CNS metastases of acute lymphocytic leukemia; and gestational trophoblastic tumors
3. Method of administration: IV push, intrathecal, and IM
4. Side effects/toxicities: myelosuppression, nausea, vomiting, stomatitis (severe with high doses), photosensitivity, neurotoxicity and renal toxicity with high doses, hepatic toxicity, gastrointestinal ulcerations, pulmonary infiltrates, and pulmonary fibrosis
5. Considerations
 - a. Patient to avoid folic acid as it may reduce the antitumor effect of methotrexate

- b. High-dose administration
 - 1) Monitor serum methotrexate levels until 0 to 1 mmol
 - 2) Ensure adequate hydration before and after administration
 - 3) Within 24 hours after high-dose administration, administer leucovorin calcium (citrovorum factor)

EE. Mitomycin (Mutamycin)

1. Classification
 - a. Pharmacologic category: antitumor antibiotic
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: vesicant
2. Indications: cancers of the breast, head and neck, lung, stomach, pancreas, esophagus, colon, and bladder
3. Method of administration: IV push, bladder instillation, and intra-arterial
4. Side effects/toxicities: myelosuppression, alopecia, stomatitis, nausea, vomiting, fatigue, interstitial pneumonitis, and hemolytic uremic syndrome
5. Considerations
 - a. Administer through the injection port of a free-flowing IV
 - b. Nadir occurs 4 to 8 weeks after drug administration

FF. Mitoxantrone Hydrochloride (Novantrone)

1. Classification
 - a. Pharmacologic category: antitumor antibiotic
 - b. Drug specificity: cell cycle-nonspecific
 - c. Group: vesicant
2. Indications: breast cancer, lymphoma, and acute nonlymphocytic leukemia
3. Method of administration: IV push and intermittent infusion
4. Side effects/toxicities: myelosuppression, nausea and vomiting, alopecia, stomatitis, and cardiac toxicity (arrhythmia if patient was treated with doxorubicin)
5. Considerations
 - a. Risk of cardiac toxicity is increased with prior anthracycline use, chest irradiation, or pre-existing cardiac disease
 - b. Instruct patient that urine may turn blue-green and sclera may turn bluish after drug administration

GG. Paclitaxel (Taxol)

1. Classification
 - a. Pharmacologic category: miscellaneous
 - b. Drug specificity: cell cycle-specific
 - c. Category: irritant
2. Indications: metastatic ovarian, breast, nonsmall-cell lung, and head and neck cancers; and Kaposi's sarcoma
3. Method of administration: continuous or intermittent infusion
4. Side effects/toxicities: myelosuppression, peripheral neuropathy, alopecia, facial flushing, malaise, fatigue, peripheral neuropathy (dose-limiting), and hypersensitivity reaction
5. Considerations
 - a. Use non-PVC containers and administration sets

- b. Use a 0.2 micron filter
- c. Premedicate with dexamethasone, diphenhydramine, and an H₂ antagonist (e.g. ranitidine, cimetidine, or famotidine) to reduce the incidence of hypersensitivity reactions

HH. Paclitaxel Protein-bound Particles (Abraxane)

1. Classification
 - a. Pharmacologic category: plant alkaloid
 - b. Drug category: cell cycle-specific
 - c. Category: irritant
2. Indication: breast cancer
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, peripheral neuropathies, ocular/visual disturbances, hypotension, arrhythmia, alopecia, nausea, vomiting, diarrhea, stomatitis, hepatic toxicity, fatigue, and flu-like symptoms
5. Considerations
 - a. Is not a substitute for paclitaxel
 - b. Unlike paclitaxel, hypersensitivity reactions are unlikely
 - c. No special tubing or filter is needed

II. Pemetrexed (Alimta)

1. Classification
 - a. Pharmacologic category: antimetabolite
 - b. Drug specificity: cell cycle-specific
 - c. Category: nonvesicant
2. Indications: lung cancer and mesothelioma
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, nausea, constipation, diarrhea, stomatitis, rash, and dyspnea
5. Considerations
 - a. Dexamethasone is given orally the day before, the day of, and the day after treatment to prevent rash
 - b. Folic acid is given orally throughout treatment
 - c. Vitamin B₁₂ is given IM every three cycles

JJ. Oxaliplatin (Eloxatin)

1. Classification
 - a. Pharmacologic category: alkylating agent
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: irritant
2. Indication: colorectal cancer
3. Method of administration: intermittent infusion
4. Side effects/toxicities: acute sensory neuropathy precipitated by exposure to cold, peripheral neuropathy, myelosuppression, nausea, vomiting, diarrhea, hepatic toxicity, and delayed hypersensitivity reactions
5. Considerations
 - a. Use with dextrose 5% in water; do not use sodium chloride solutions
 - b. Teach patient to minimize exposure to cold for 3 to 5 days after receiving oxaliplatin

- c. Hypersensitivity reactions are more likely to occur after 8 to 12 cycles of oxaliplatin

KK. Streptozocin (Zanosar)

1. Classification
 - a. Pharmacologic category: nitrosourea
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: irritant
2. Indications: metastatic islet cell carcinoma of the pancreas and carcinoid tumor
3. Method of administration: intermittent infusion
4. Side effects/toxicities: myelosuppression, nausea, vomiting, diarrhea, hyperglycemia, hypophosphatemia, anuria, elevated liver enzymes, hypoalbuminemia, and renal toxicity
5. Considerations
 - a. Extravasation may cause necrosis and tissue lesions
 - b. Ensure adequate hydration of 2 to 3 L/day
 - c. Monitor urine for proteinuria
 - d. Rapid administration may cause burning along the vein

LL. Thiotepa (Thioplex)

1. Classification
 - a. Pharmacologic category: alkylating agent
 - b. Drug specificity: cell cycle-nonspecific
 - c. Category: nonvesicant
2. Indications: cancers of the brain, breast, ovary, and bladder; Hodgkin's disease; lymphoma; and in preparation for bone marrow transplant
3. Method of administration: IV push, intracavitary, intravesicular, and intrathecal
4. Side effects/toxicities: myelosuppression, alopecia, anaphylaxis, cystitis, fatigue, fever, rash, stomatitis, itching, weakness, and mild nausea
5. Considerations
 - a. Nadir may last up to 30 days
 - b. May cause sterility in both sexes
 - c. May cause pain at infusion site

MM. Topotecan (Hycamtin)

1. Classification
 - a. Pharmacologic category: camptothecins
 - b. Drug specificity: cell cycle-specific
 - c. Category: irritant
2. Indications: acute lymphocytic leukemia, metastatic ovarian cancer, NSCLC, and solid tumors
3. Method of administration: intermittent or continuous infusion
4. Side effects/toxicities: myelosuppression, diarrhea, alopecia, nausea, vomiting, stomatitis, constipation, fatigue, and headache
5. Considerations
 - a. Monitor renal function

NN. Vinblastine (Velban)

1. Classification
 - a. Pharmacologic category: vinca alkaloid
 - b. Drug specificity: cell cycle-specific
 - c. Category: vesicant
2. Indications: Hodgkin's disease; histiocytosis; Kaposi's sarcoma; cancer of the testes; squamous cell cancer of the head and neck
3. Method of administration: IV push
4. Side effects/toxicities: myelosuppression, anorexia, constipation, alopecia, nausea, vomiting, hypertension, bronchospasm, jaw pain, and paresthesia
5. Considerations
 - a. Administer IV push via injection port of a free-flowing IV
 - b. Avoid concomitant intake of grapefruit juice as it may increase the toxicity of vinblastine

OO. Vincristine (Oncovin)

1. Classification
 - a. Pharmacologic category: vinca alkaloid
 - b. Drug specificity: cell cycle-specific
 - c. Category: vesicant
2. Indications: acute lymphocytic leukemia, CML, Hodgkin's disease, NHL, melanoma, sarcoma, Wilms' tumor, cancer of the breast, small cell lung cancer, multiple myeloma, and neuroblastoma
3. Method of administration: IV push
4. Side effects/toxicities: alopecia, constipation, nausea, vomiting, diarrhea, paralytic ileus, urinary retention, paresthesias, peripheral neuropathy, rash, and fever
5. Considerations
 - a. Difficulty with gait, ataxia, foot or wrist drop, and muscle wasting may occur with prolonged administration
 - b. Reduce the dose in the presence of a significant liver disease

PP. Vinorelbine (Navelbine)

1. Classification
 - a. Pharmacologic category: vinca alkaloid
 - b. Drug specificity: cell cycle-specific
 - c. Group: vesicant
2. Indications: NSCLC and breast cancer
3. Method of administration: IV push
4. Side effects/toxicities: myelosuppression, nausea, vomiting, alopecia, mucositis, neurotoxicity, and peripheral neuropathy
5. Considerations
 - a. Infuse over 6 to 10 minutes into the side arm of free-flowing IV using the port closest to the IV bag (not the patient)
 - b. After drug administration, flush the VAD with at least 75 to 125 mL of IV fluid



X. Biotherapy in Cancer Treatment

A. Biologic Response Modifiers

1. Agents that increase the immune system's ability to cause cancer cell death, decrease some of the side effects of standard chemotherapy, and with some agents, directly cause cell death
2. Includes colony-stimulating factors (CSFs), gene therapy, monoclonal antibodies, vaccines, and nonspecific biotherapeutic agents

B. Colony-stimulating Factors

1. Regulate the production and proliferation of stem cells in the bone marrow
2. Epoetin alfa (Epoen, Procrit)
 - a. Indications: treatment of chemotherapy-induced anemia; used only in nonhematological malignancies where cure is not the goal of the treatment; increases RBC production
 - b. Method of administration: subcutaneous; IV push after dialysis
 - c. Side effects/toxicities: nausea, vomiting, hypertension, fever, fatigue, headache, and thrombotic complications
 - d. Considerations: Black box warning: may increase the risk for death, life-threatening cardiovascular events and stroke when administered to a target hemoglobin level of >12 g/dL in patients with cancer
3. Darbepoetin alpha (Aranesp)
 - a. Indications: treatment of chemotherapy-induced anemia; used only in nonhematological malignancies where cure is not the goal of the treatment; increases RBC production
 - b. Method of administration: subcutaneous or IV push
 - c. Side effects/toxicities: fatigue, peripheral edema, rash, headache, dizziness, bone pain, fever, and diarrhea
 - d. Considerations: Black box warning: may increase the risk for death, life-threatening cardiovascular events and stroke when administered to a target hemoglobin level of >11 g/dL
4. Filgrastim (G-CSF, Neupogen)
 - a. Indications: to reduce the risk of infection in patients receiving myelosuppressive antineoplastic treatment with nonhematological malignancies; increases neutrophil production
 - b. Method of administration: subcutaneous or IV push
 - c. Side effects/toxicities: bone pain, nausea, vomiting, and fever
 - d. Considerations: begin administration at least 24 hours after chemotherapy administration and continue daily for up to two weeks or until ANC is $>10,000/\text{mm}^3$
5. Pegfilgrastim (Neulasta)
 - a. Indications: to reduce the risk of infection in patients receiving myelosuppressive antineoplastic treatment with nonhematological malignancies; increases neutrophil production
 - b. Method of administration: subcutaneous
 - c. Side effects/toxicities: bone pain, headache, abdominal pain, nausea, vomiting, constipation, diarrhea, anorexia, stomatitis, and mucositis
 - d. Considerations: given 24 hours after chemotherapy administration once per cycle but not within 14 days prior to the next chemotherapy treatment

6. Sargramostim (Leukine, GM-CSF)
 - a. Indications: to shorten the recovery of neutrophils after induction chemotherapy for patients with AML; stimulates production of granulocytes and macrophages
 - b. Method of administration: subcutaneous or IV push
 - c. Side effects/toxicities: bone pain, rash, flushing, dyspnea, and fluid retention
 - d. Considerations: dilute with sodium chloride prior to IV administration
7. Oprelvekin (Interleukin-11, Neumega)
 - a. Indications: reduces the need for platelet transfusions and prevents severe thrombocytopenia in patients receiving chemotherapy; stimulates the production of platelets
 - b. Method of administration: subcutaneous
 - c. Side effects/toxicities: fluid retention, atrial fibrillation, blurred vision, nausea, vomiting, diarrhea, and mucositis
 - d. Considerations: use with caution in patients with history of CHF and those taking chronic diuretics; given daily starting 6 to 24 hours after chemotherapy administration and continued until postnadir platelets are $\geq 50,000$ cells/mL

C. Human Keratinocyte Growth Factor

1. Palifermin (Kepivance)
 - a. Indications: to decrease the incidence of severe stomatitis by stimulating the production of epithelial cells in patients with hematologic cancers receiving high-dose chemotherapy and radiation
 - b. Method of administration: IV push
 - c. Side effects/toxicities: rash, pain, muscle aches, taste alterations, and tongue thickening
 - d. Considerations: given for 3 days before and 3 days after myelosuppressive chemotherapy; doses must be consecutive

D. Gene Therapy

1. Regulates the production of antibodies and the functions of B and T cells; interrelates with antigen-presenting cells and natural killer (NK) cells
2. Interferon alfa-2b (Intron A)
 - a. Indications: for the treatment of hairy-cell leukemia, AIDS-related Kaposi's sarcoma, malignant melanoma, and NHL; prevents reproduction of tumor cells, inhibits the duplication of viruses, and enhances the immune response
 - b. Method of administration: subcutaneous, IV push, intermittent or continuous infusion, intramuscular
 - c. Side effects/toxicities: neutropenia, thrombocytopenia, chills, fever, fatigue, headache, muscle and joint pain, nausea, diarrhea, anorexia, dizziness, confusion, depression, tachycardia, chest pain, dysrhythmias, renal and hepatic dysfunction, impotence, menstrual irregularities, rash, hair thinning, and skin dryness
 - d. Considerations
 - 1) May cause severe hypersensitivity reactions
 - 2) Pre-treatment with acetaminophen may decrease flu-like symptoms
 - 3) Induction therapy is given as an IV infusion 5 days per week for 4 weeks; maintenance therapy is given subcutaneously three times per week for 48 weeks

3. Interleukin (IL-2, Aldesleukin, Proleukin)
 - a. Indications: treatment of renal cell carcinoma and metastatic melanoma
 - b. Method of administration: subcutaneous, intermittent infusion
 - c. Side effects/toxicities: usually severe requiring intensive care; leukopenia, thrombocytopenia, anemia, fever, chills, fatigue, muscle and joint pain, hypotension, nausea, vomiting, anorexia, diarrhea, rash, and cardiac arrhythmias
 - d. Considerations: infused over 15 minutes every 8 hours for 14 doses with 9 days of rest and then repeated for up to 14 more doses; toxicities are dose-dependent

E. Monoclonal Antibodies

1. Artificially produced proteins (antibodies) that recognize an antigen (cancer cell) and initiate an immune response to kill the cancer cell; made from murine (mouse), humanized, or human proteins
2. Alemtuzumab (Campath)
 - a. Indications: treatment of B-cell CLL (B-CLL)
 - b. Method of administration: IV infusion over 2 hours, subcutaneous
 - c. Side effects/toxicities: anemia, neutropenia, lymphopenia, thrombocytopenia, infection, infusion reactions, cytomegalovirus infections, nausea, vomiting, insomnia, and diarrhea
 - d. Considerations: diphenhydramine and acetaminophen given as premedications; administered three times per week for up to 12 weeks
3. Bevacizumab (Avastin)
 - a. Indications: metastatic colon or rectal cancer, nonsquamous NSCLC, metastatic HER-2 negative breast cancer, glioblastoma, and renal cell carcinoma
 - b. Method of administration: IV—initial dose over 90 minutes; subsequent doses over 30 to 60 minutes
 - c. Side effects/toxicities: gastrointestinal perforation, non-GI fistula formation, wound healing alteration, hemorrhage, arterial thromboembolic events, hypertension, neutropenia, proteinuria, CHF, infusion reactions (<3%), arthralgia, asthenia, pain, and headache
 - d. Considerations
 - 1) Discontinue the agent at least 4 weeks prior to elective surgery and do not start it until 28 days following major surgery and until wound is healed
 - 2) Monitor urine protein periodically, every cycle, or every other cycle
4. Cetuximab (Erbix)
 - a. Indications: treatment of squamous cell carcinoma of the head and neck and metastatic colorectal cancers
 - b. Method of administration: IV—loading dose over 2 hours, maintenance dose over 1 hour
 - c. Side effects/toxicities: rash, pruritus, nail changes, headache, diarrhea, and infection
 - d. Considerations: premedicate with diphenhydramine; usually given weekly; monitor for severe hypersensitivity reactions
5. Eculizumab (Solaris)
 - a. Indications: treatment of paroxysmal nocturnal hemoglobinuria (PNH) to reduce hemolysis
 - b. Method of administration: intermittent infusion

- c. Side effects/toxicities: meningitis, septicemia, progression of PNH, back pain, headache, nasopharyngitis, and nausea
 - d. Considerations: at least 2 weeks prior to initiating therapy, the patient must receive a meningococcal vaccine if not previously vaccinated; a booster dose is given to those previously vaccinated; infused over 35 minutes
6. Panitumumab (Vectibix)
- a. Indications: treatment of metastatic colorectal cancer that expresses epithelial growth factor receptor (EGFR) when the disease progresses after treatment with 5-FU, oxaliplatin, and irinotecan
 - b. Method of administration: intermittent infusion
 - c. Side effects/toxicities: abdominal pain, constipation, diarrhea, hypomagnesemia, paronychia, fatigue, nausea, skin toxicities, and infusion reactions
 - d. Considerations: administered over 60 minutes every 14 days: use a 0.2- or 0.22 micron filter for administration
7. Rituximab (Rituxan)
- a. Indications: treatment of CD20-positive B-cell NHL and CLL
 - b. Method of administration: intermittent infusion; never IV push
 - c. Side effects/toxicities: infusion reactions, chills, fever, and infection
 - d. Considerations: premedicate with diphenhydramine and acetaminophen to prevent infusion reactions. Infusion rate increases from 50 mg/hour for the initial dose up to 400 mg/hour with rate increasing every 30 minutes provided there is no evidence of adverse events. Subsequent doses are started at 100 mg/hour and increased every 30 minutes to a maximum of 400 mg/hour
8. Trastuzumab (Herceptin)
- a. Indications: adjuvant treatment of HER2-overexpressing breast cancer that is node-positive or negative
 - b. Method of administration: intermittent infusion
 - c. Side effects/toxicities: cardiomyopathy, hypersensitivity reactions, dyspnea, pulmonary toxicities, pain, and infection
 - d. Considerations: if a hypersensitivity reaction occurs, with subsequent infusions premedicate with diphenhydramine and/or corticosteroids. Administer over 90 minutes for first infusion. Subsequent infusions are infused over 30 to 90 minutes

F. Vaccines

1. Quadrivalent human papillomavirus recombinant vaccine (Gardasil)
- a. Indications: vaccination of females aged 9 to 26 to prevent diseases caused by human papillomavirus 6, 11, 16, and 18 such as cervical cancer, genital warts, cervical adenocarcinoma in situ, cervical intraepithelial neoplasia (CIN), vulvar intraepithelial neoplasia (VIN), vaginal intraepithelial neoplasia (VaIN), and cervical epithelial neoplasia
 - b. Method of administration: IM
 - c. Side effects/toxicities: injection site discomfort, fever
 - d. Considerations: given in deltoid muscle or anterolateral thigh in 3 separate 0.5 mL doses

G. Targeted Therapies

1. Targeted therapies: moderate, control, and/or kill cancer cells
- a. Agents that target growth factor receptors in extracellular pathways are monoclonal antibodies or large molecules

- b. Those that target intracellular pathways are tyrosine kinase receptors or small molecules
- 2. Oral therapies
 - a. Dasatinib (Sprycel) for CML; targets multikinase inhibitors
 - b. Erlotinib (Tarceva) for NSCLC and pancreatic cancer; targets the EGFR (epidermal growth factor receptor) single tyrosine kinase inhibitor
 - c. Lapatinib (Tykerb) for breast cancer; targets the EGFR and HER2 tyrosine kinase inhibitors
 - d. Nilotinib (Tasigna) for CML; targets the BCR-ABL kinase
 - e. Sorafenib (Nexavar) for renal cell and hepatocellular cancers; targets the multikinase inhibitor
 - f. Sunitinib (Sutent) for GIST (gastrointestinal stromal tumor) and renal cell cancer; targets the multikinase inhibitor
- 3. IV targeted therapies
 - a. Temsirolimus (Torisel)
 - 1) Indications: advanced renal cell cancer; targets mTOR receptor
 - 2) Method of administration: intermittent infusion
 - 3) Side effects/toxicities: rash, weakness, fatigue, mucositis, nausea, edema, and anorexia
 - 4) Considerations: premedicate with diphenhydramine 30 minutes prior to the start of the infusion; administer weekly over 30 to 60 minutes; may cause hyperglycemia and abnormal wound healing
 - b. Bortezomib (Velcade)
 - 1) Indications: treatment of multiple myeloma or mantle cell lymphoma
 - 2) Method of administration: intermittent infusion
 - 3) Side effects/toxicities: peripheral neuropathy, nausea, vomiting, diarrhea, hypotension, fatigue, and myelosuppression
 - 4) Considerations: given as IV bolus over 3 to 5 seconds; given with oral prednisone and/or oral melphalan for nine 6-week cycles

PART II: BIOLOGIC THERAPY



I. Overview

- A. A biologic therapy includes the use of agents derived from biologic sources or agents that affect biologic responses
- B. Although biologic therapies were used to modify the body's immune responses, the scope has widened as many biologic agents are extraordinarily specific in their interactions
- C. Biologic agents differ from most drugs as they are not small chemical compounds but are proteins structurally similar to autologous proteins
- D. Biologic agents are not metabolized like drugs but are processed like other proteins in the body



II. Immune System Review

A. Innate (nonspecific) Immunity

1. The first line of defense against antigens and includes mechanical barriers such as the intact skin and mucous membrane
2. This type of immunity is present before exposure to an antigen and is not enhanced by subsequent exposures
3. If first line defense fails, the innate immune system has a second-line of defense including complement, phagocytes, and natural killer (NK) cells

B. Adaptive (Specific or Acquired) Immunity

1. Is characterized by specific recognition of foreign organisms and a memory response allowing the immune system to increase the ability to respond and defend the body with successive exposures to infectious organisms
2. There are two branches of the adaptive immune responses
 - a. Humoral immunity
 - 1) Involves the production of antibody molecules in response to an antigen and is mediated by B lymphocytes
 - 2) B lymphocytes (B cells) are specialized cells that develop from the stem cells in the bone marrow
 - 3) Mature B cells are found in the bone marrow, lymph nodes, spleen, parts of the intestines, and some in the bloodstream
 - 4) When B cells are stimulated by an antigen, they respond by maturing into plasma cells
 - 5) Plasma cells are responsible for producing antibodies or immunoglobulins (Igs)
 - 6) Igs interact with specific antigens to protect the host from potentially harmful substances
 - 7) Five classes of Igs
 - a) IgG (Ig gamma)
 - Major Ig in the blood
 - Enters the tissue space and coats microorganisms speeding destruction
 - Only Ig that crosses the placenta and passes immunity from mother to newborn
 - b) IgA (Ig alpha)
 - Guards the entrance to the body
 - Found in tears, saliva, and secretions or the respiratory and GI tract
 - c) IgD (Ig delta)
 - Remains attached to the B cells
 - Plays a key role in initiating early B-cell response
 - d) IgE (Ig epsilon)
 - Present only in trace amount and is responsible for symptoms of allergy
 - e) IgM (Ig mu)
 - Remains in the bloodstream where it is effective in killing bacteria

- b. Cell-mediated immunity
 - 1) Involves the production of cytotoxic T lymphocytes, activated macrophages, activated NK cells, and cytokines in response to an antigen
 - 2) Mediated by T lymphocytes also called T cells
 - 3) Mature T cells populate the spleen, lymph nodes, bone marrow, and blood
 - 4) T cells have molecules on their surfaces that are similar to antibodies and recognize antigens
 - 5) T cells do not produce antibodies; they directly attack foreign antigens such as viruses, fungi, or transplanted tissue
 - 6) T cells act as regulators of the immune system and vary in types and functions
 - a) Cytotoxic T lymphocytes (killer T cells)
 - Performs actual destruction of the invading organism
 - Responds to foreign tissue in the body
 - Works by directly binding to their target and kills it
 - b) Helper T cells
 - Assist B lymphocytes in the production of antibodies
 - Assist the killer T lymphocytes in attacking foreign substances
 - c) Regulatory T lymphocytes
 - Act as a thermostat to the lymphocyte system
 - Suppress or turn off other T lymphocytes
 - d) NK cells
 - Come from the bone marrow and present in low numbers in the tissues and blood stream
 - Play an important role in killing cells infected with viruses
 - Believe to play a role in preventing cancer
 - e) Macrophages
 - Large white blood cells found in the lungs, kidneys, brain, and liver
 - Act like scavengers removing debris and worn out cells from the body
 - Produces monokines, a powerful chemical signal vital to the immune response
 - f) Cytokines
 - Potent and diverse chemical messengers that serve as chief communication signals for the T cells
 - Promote cell growth, cell activation, direct cellular traffic, and destroy target cells
 - Interleukins (ILs)
 - Messengers between leukocytes
 - Also called lymphokines or monokines
 - Chemokines
 - Released at the site of injury or infection where it attracts other immune cells to repair damage and defend against infection
 - Interferons
 - Naturally occurring cytokines that boost the immune system's ability to recognize cancer as a foreign invader



III. Immune System Disorders

A. Two General Categories

1. Excessive immune response
 - a. Includes disorders in which the immune system is over functioning or hyperfunctioning
 - b. Types
 - 1) Autoimmunity
 - 2) Hypersensitivity disorders
2. Deficient immune response
 - a. Includes disorders in which the immune response is ineffective because of a congenital, genetic, or acquired dysfunction
 - b. Examples
 - 1) Severe combined immunodeficiency disorder
 - 2) DiGeorge syndrome
 - 3) Selective IgA deficiency
 - 4) Secondary immunodeficiencies associated with white blood cell malignancies
 - c. Human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) is a primary acquired immunodeficiency disorder

B. Autoimmune Disorders

1. The failure of the immune system to distinguish between self-antigens and foreign antigens because of an interaction of a wrong environment with the wrong genes
2. When a self-antigen becomes immunogenic, it cannot be eliminated resulting in the persistent and destructive inflammation
3. Classic sign: inflammation (redness, heat, swelling, and pain)
4. Treatment goal: reduce inflammation
5. Autoimmune disorders by system
 - a. Neurologic
 - 1) Multiple sclerosis
 - 2) Myasthenia gravis
 - 3) Guillain-Barre syndrome
 - 4) Autoimmune uveitis
 - b. GI
 - 1) Crohn's disease
 - 2) Ulcerative colitis
 - 3) Primary biliary cirrhosis
 - 4) Autoimmune hepatitis
 - c. Hematologic
 - 1) Autoimmune hemolytic anemia
 - 2) Pernicious anemia
 - 3) Autoimmune thrombocytopenia
 - 4) Temporal arteritis
 - 5) Antiphospholipid syndrome
 - 6) Vasculitides (Wegener's granulomatosis)
 - 7) Behcet's syndrome
 - 8) Idiopathic thrombocytopenia purpura

- 9) Myocarditis
- 10) Polyarteritis nodosa
- d. Integumentary
 - 1) Psoriasis
 - 2) Dermatitis herpetiformis
 - 3) Pemphigus vulgaris/pemphigoid
 - 4) Vitiligo
 - 5) Alopecia areata
 - 6) Dermatomyositis
- e. Endocrine
 - 1) Type 1 diabetes
 - 2) Grave's disease
 - 3) Hashimoto's thyroiditis
 - 4) Autoimmune oophoritis/orchiditis
 - 5) Autoimmune adrenal gland disease
 - 6) Glomerulonephritis
 - 7) Thyroiditis
- f. Musculoskeletal
 - 1) Rheumatoid arthritis
 - 2) Systemic lupus erythematosus
 - 3) Scleroderma/systemic sclerosis
 - 4) Polymyositis
 - 5) Ankylosing spondylitis
 - 6) Sjogren syndrome
 - 7) Psoriatic arthritis

C. Immune Deficiency Disorders

1. An immune deficiency disorder results when either part of the immune system (innate or adaptive) is absent or its function is hampered
2. Two types
 - a. Primary immune deficiency: results when there is a intrinsic (inborn) defect in the cells of the immune system
 - b. Secondary immune deficiency: caused by an extrinsic environmental factor or agent
3. Primary immune deficiency (PID) disorders
 - a. A group of disorders caused by basic defects in immune function that are intrinsic to, or inherent in, the cells and tissues of the immune system
 - b. There are over 150 PID disorders, ranging from common to rare, affecting a single cell or a protein or more than one component of the immune system
- c. Examples
 - 1) Agammaglobulinemia (X-linked and autosomal)
 - 2) Hypogammaglobulinemia with impaired specific antibody production
 - a) Common variable immunodeficiency
 - b) Hyper IgM syndrome
 - c) Transient hypogammaglobulinemia
 - 3) Normogammaglobulinemia with selective antibody deficiency
 - a) Wiskott-Aldrich syndrome
 - b) Specific polysaccharide antibody deficiency and/or lacunar antibody deficiencies

4. Secondary immune deficiency disorders
 - a. Are conditions that impair immune functions resulting from other processes such as physical, psychosocial, nutritional, environmental, and pharmacological factors singly or combined
 - b. Examples
 - 1) CLL with antibody deficiency and recurrent infection
 - 2) Pediatric HIV infection
 - 3) Hypogammaglobulinemia and/or specific antibody deficiency caused by chemotherapy and/or monoclonal antibody treatment



IV. Biologic Therapy for Autoimmune Disorders

A. Overview

1. The use of biologic therapy may not always be the first-line treatment choice and used only after traditional symptom-based treatment has failed
2. Can be used for the treatment of patients with autoimmune disorders and cancer
3. Traditional symptom-based treatment may include
 - a. Anti-inflammatory drugs
 - b. Corticosteroids
 - c. Immunosuppressant medication
 - d. Surgery
4. Biologic agents are administered either by IV infusion or subcutaneous injection
5. Monoclonal antibodies
 - a. Are biologic agents produced by a technique called “hybridoma”
 - b. Hybridoma technique fuses an antibody-producing cell with a myeloma cell line resulting in an immortal hybrid cell that produces a single antibody recognizing only a single antigen
 - c. Drug name
 - 1) The generic names of monoclonal antibodies end in “mab”
 - 2) The infixes preceding the suffix stem identify the target disease state and the product source
 - 3) Examples:
 - umab (human)
 - omab (mouse)
 - ximab (chimera)
 - zumab (humanized)

B. Methods of Administration

1. IV infusion
 - a. Usually administered via peripheral venous catheter
 - b. Follow manufacturer’s recommendations for rate and use of filter
 - c. Vital signs monitored during and following infusion
2. Subcutaneous injection
 - a. Administered weekly or every other week depending on the agent
 - b. Administered by healthcare professional or patient/caregiver

C. Monoclonal Antibodies

1. Adalimumab (Humira)
 - a. Classification: TNF (tumor necrosis factor) inhibitor
 - b. Indications
 - 1) Rheumatoid arthritis
 - 2) Psoriatic arthritis
 - 3) Ankylosing spondylitis
 - 4) Juvenile idiopathic arthritis
 - 5) Crohn's disease
 - 6) Plaque psoriasis
 - c. Method of administration: subcutaneous injection
 - d. Mechanism of action: binds specifically to TNF- α and blocks its interaction with p55 and p75 cell surface receptor
 - e. Side effects/toxicities
 - 1) Local injection site reaction
 - 2) Malignancies
 - 3) Immunosuppression/infections
 - 4) Hepatotoxicity
 - 5) Hematological events
 - 6) Hepatitis B reactivation
 - 7) Neurological events
 - 8) Cardiac events
 - f. Considerations
 - 1) Self-administered by patient
 - 2) Provide instruction on how to administer subcutaneously
2. Certolizumab pegol (Cimzia)
 - a. Classification: TNF inhibitor
 - b. Indication: Crohn's disease
 - c. Method of administration: subcutaneous injection
 - d. Mechanism of action: blocks and inhibits human TNF- α
 - e. Side effects/toxicities
 - 1) Local injection site reaction
 - 2) Malignancies
 - 3) Immunosuppression/infection
 - 4) Hematological events
 - 5) Hepatitis B reactivation
 - 6) Neurological events
 - 7) Cardiac events
 - f. Considerations
 - 1) Self-administered by patient
 - 2) Provide instruction on how to administer subcutaneously
3. Golimumab (Simponi)
 - a. Classification: TNF inhibitor
 - b. Indications
 - 1) Rheumatoid arthritis
 - 2) Psoriatic arthritis
 - 3) Ankylosing spondylitis
 - c. Method of administration: subcutaneous injection
 - d. Mechanism of action: prevents binding of TNF- α to its receptors inhibiting the biologic activity of TNF- α

- e. Side effects/toxicities
 - 1) Serious infections
 - 2) Invasive fungal infections
 - 3) Hepatitis B reactivation
 - 4) Heart failure worsening or new onset
 - 5) Demyelinating disorders, exacerbation, or new onset
 - 6) Hypersensitivity reactions
 - 7) Upper respiratory infections
 - 8) Nasopharyngitis
 - 9) Injection site reactions
 - f. Considerations
 - 1) Self-administered by patient
 - 2) Provide instruction on how to administer subcutaneously
4. Natalizumab (Tysabri)
- a. Classification: alpha 4 integrin inhibitor
 - b. Indications
 - 1) Relapsing form of multiple sclerosis
 - 2) Crohn's disease
 - c. Method of administration: IV infusion
 - d. Mechanism of action: binds and inhibits alpha4-mediated adhesion of leukocytes to their counter receptors
 - e. Side effects/toxicities
 - 1) Infusion reactions
 - 2) Progressive multifocal leukoencephalopathy (PML)
 - 3) Immunosuppression/infections
 - 4) Hepatotoxicity
 - f. Considerations
 - 1) Administer over 1 hour
 - 2) Tysabri has a Risk Evaluation and Mitigation Strategy (REMS), which allows only prescribers registered in the Tysabri Touch program to prescribe this medication
 - 3) Assess patient before each infusion
 - 4) Monitor closely during infusion
 - 5) Observe patient 1 hour after the completion of infusion
5. Infliximab (Remicade)
- a. Classification: TNF- α inhibitor
 - b. Indications
 - 1) Rheumatoid arthritis
 - 2) Ankylosing spondylitis
 - 3) Psoriatic arthritis
 - 4) Crohn's disease
 - 5) Pediatric Crohn's disease
 - 6) Ulcerative colitis
 - 7) Pediatric ulcerative colitis
 - 8) Plaque psoriasis
 - c. Method of administration: IV infusion
 - d. Mechanism of action: neutralizes biologic activities of TNF- α by binding with high affinity to soluble and transmembrane forms of TNF- α ; inhibits binding of TNF- α with its receptors
 - e. Side effects/toxicities
 - 1) Infusion reactions
 - 2) Malignancies

- 3) Serious infections
- 4) Immunosuppression
- 5) Hepatotoxicity
- 6) Hematologic events
- 7) Hepatitis B reactivation
- 8) Neurologic/demyelinating disorders
- 9) Cardiac events
- f. Considerations
 - 1) Administer by infusion over 2 hours
 - 2) Filter required for infusion
 - 3) Administer premedications as ordered
 - 4) Obtain orders for the management of potential infusion reactions as needed
 - 5) Monitor patient closely during infusion
 - 6) Observe patient 30 minutes after the completion of infusion
- 6. Rituximab (Rituxan)
 - a. Classification: B-cell-directed therapy
 - b. Indications: NHL, rheumatoid arthritis
 - c. Method of administration: IV infusion
 - d. Mechanism of action: binds to CD20 antigen on B lymphocytes and recruits immune effector function to mediate B-cell lysis
 - e. Side effects/toxicities
 - 1) Infusion reactions
 - 2) Malignancies
 - 3) PML
 - 4) Serious infections
 - 5) Immunosuppression
 - 6) Hepatotoxicity
 - 7) Hematologic events
 - 8) Hepatitis B reactivation
 - 9) Neurologic/demyelinating disorders
 - 10) Cardiac events
 - f. Considerations
 - 1) Administer premedications before each infusion
 - 2) Monitor patient closely during infusion
- 7. Tocilizumab (Actemra)
 - a. Classification: IL-6 inhibitor
 - b. Indications
 - 1) Rheumatoid arthritis
 - 2) Systemic juvenile idiopathic arthritis
 - c. Method of administration: IV infusion
 - d. Mechanism of action: binds specifically to soluble and membrane-bound IL-6 receptors and has been shown to inhibit IL-6-mediated signaling through these receptors
 - e. Side effects/toxicities
 - 1) Serious infections
 - 2) GI perforation
 - 3) Hypersensitivity reactions
 - 4) Treatment-related changes in neutrophils, platelets, lipids, and liver function test
 - f. Considerations
 - 1) Administer by infusion over 1 hour

- 2) Not recommended for patients with an ANC below 2,000 per mm^3 , platelet count below 100,000 per mm^3 , ALT or AST 1.5 times the upper limit of normal
 - 3) Monitor patient closely during infusion
8. Ustekinumab (Stelara)
- a. Classification: IL-12 and IL-23 inhibitors
 - b. Indications: moderate-to-severe plaque psoriasis in adults
 - c. Method of administration: subcutaneous injection
 - d. Mechanism of action: binds with high affinity and specificity to the p40 protein subunit used by both IL-12 and IL-23 cytokines
 - e. Side effects/toxicities
 - 1) Serious infections
 - 2) Malignancies
 - 3) Anaphylaxis or serious allergic reactions
 - 4) Reversible posterior leukoencephalopathy syndrome (RPLS)
 - f. Considerations
 - 1) Self-administered by patient or healthcare professional
 - 2) Provide instruction on how to administer subcutaneously

D. Fusion Proteins

1. Abatacept (Orencia)
 - a. Classification: T-cell costimulation modulator
 - b. Indication: adult rheumatoid arthritis, juvenile idiopathic arthritis
 - c. Method of administration: IV infusion and subcutaneous injection
 - d. Mechanism of action: inhibits T-cell activation by binding to CD80 and CD86, thereby blocking interaction with CD28
 - e. Side effects/toxicities
 - 1) Infusion reactions
 - 2) Malignancies
 - 3) Serious infections
 - 4) Immunosuppression
 - f. Considerations
 - 1) IV infusion
 - a) Administer over 30 minutes
 - b) Filter is required
 - c) Prepare medication using only a silicone-free disposable syringe
 - d) Assess patient prior to infusion
 - e) Monitor during infusion
 - 2) Subcutaneous injection
 - a) Self-administered by patient
 - b) Provide instruction on how to administer subcutaneously
2. Etanercept (Enbrel)
 - a. Classification: TNF inhibitor
 - b. Indications
 - 1) Rheumatoid arthritis
 - 2) Psoriatic arthritis
 - 3) Ankylosing spondylitis
 - 4) Juvenile idiopathic arthritis
 - 5) Plaque psoriasis
 - c. Method of administration: subcutaneous injection

- d. Mechanism of action: binds specifically to TNF and blocks its interaction with cell surface receptors
- e. Side effects/toxicities
 - 1) Serious infections
 - 2) Immunosuppression
 - 3) Malignancies
 - 4) Hepatotoxicity
 - 5) Hematologic events
 - 6) Hepatitis B reactivation
 - 7) Neurological events
 - 8) Cardiac events
 - 9) Local injection site reactions
- f. Considerations
 - 1) Self-administered by patient
 - 2) Provide instruction on how to administer subcutaneously

E. Interleukin (IL) Inhibitors

- 1. Anakinra (Kineret)
 - a. Classification: IL-1 inhibitor
 - b. Indication: rheumatoid arthritis
 - c. Method of administration: subcutaneous injection
 - d. Mechanism of action: blocks the biologic activity of IL-1 by completely inhibiting IL-1 binding to IL-1 type receptors
 - e. Side effects/toxicities
 - 1) Local injection site reactions
 - 2) Malignancies
 - 3) Immunosuppression
 - 4) Serious infections
 - 5) Hematologic events
 - f. Considerations
 - 1) Self-administered by patient
 - 2) Provide instruction on how to administer subcutaneously



V. Immunoglobulin (Ig) Therapy

A. Used for replacement in primary or secondary humoral antibody deficiency or for immunomodulation for autoimmune or certain infectious diseases

B. Mechanism of Action

- 1. Exact mechanism is unknown
- 2. Theories on how it works include
 - a. Inhibition of cytokines
 - b. Competition with autoantibodies
 - c. Complement "sponging"
 - d. Interference with the binding of crystallized fragments (Fc) receptors on the cells of the reticuloendothelial system
 - e. Interference with antigen recognition by T cells
 - f. Negative feedback on the factories of antibody production

C. Method of Administration

1. IV infusion
 - a. Most common method
 - b. Usually administered via peripheral venous catheter
 - c. Follow manufacturer's recommendations for the rate and use of filter
 - d. Generally well tolerated by patients
 - e. Larger doses can be administered
2. Subcutaneous infusion
 - a. Smaller doses given frequently or over a period of time
 - b. May eliminate some adverse effects associated with IV infusion
 - c. Allows for slow and gradual absorption of Ig IV product
 - d. Administered by healthcare professional or patient/caregiver

D. Ig products are made from carefully screened and tested donors. Production processes of all products include dedicated steps designed to remove and inactivate bloodborne pathogens

E. Ig (IgIV) products are lyophilized or liquid preparations that contain varying concentrations of IgA

F. Patient Factors Affecting Product Selection

1. Kidney function
2. History of diabetes
3. Hypertension
4. Stroke
5. History of thromboembolytic events
6. Product preparation time

G. Types of Immune Globulin Products

1. Gammagard SD
 - a. Indications
 - 1) Immune thrombocytopenia purpura (ITP)
 - 2) Primary immunodeficiency disease (PID)
 - 3) CLL
 - 4) Kawasaki syndrome
 - b. Method of administration: IV infusion, filter required
2. Gammagard liquid
 - a. Indication: PID
 - b. Method of administration
 - 1) IV infusion
 - 2) Subcutaneous infusion
 - 3) Filter optional
3. Carimmune NF
 - a. Indications
 - 1) Acute and chronic immune thrombocytopenic purpura
 - 2) PID
 - b. Method of administration: IV infusion; no filter required

4. Privigen 10%
 - a. Indications
 - 1) PID
 - 2) Chronic immune thrombocytopenic purpura
 - b. Method of administration: IV infusion, no filter required
5. Flebogamma
 - a. Indication: PID
 - b. Method of administration: IV infusion, filter recommended
6. Octagam 5%
 - a. Indication: PID
 - b. Method of administration: IV infusion, filter required
7. Gamunex-C 10%
 - a. Indications
 - 1) Immune thrombocytopenic purpura
 - 2) PID
 - b. Method of administration
 - 1) IV infusion
 - 2) Subcutaneous infusion
 - 3) No filter required
8. Gammaplex
 - a. Indication: primary humoral immune deficiency
 - b. Method of administration: IV infusion
9. Gammaked
 - a. Indication: PID
 - b. Method of administration
 - 1) IV infusion
 - 2) Subcutaneous infusion
10. Hizentra
 - a. Indications
 - 1) PID in adults
 - 2) PID in pediatric patients 2 years and older
 - b. Method of administration: subcutaneous infusion

H. Adverse Events Related to Ig Therapy

1. IV infusion
 - a. Occurs during the first 30 to 60 minutes of the infusion
 - b. May include
 - 1) Chills/rigors
 - 2) Back pain
 - 3) Migraine headaches
 - 4) Malaise/flu-like symptoms
 - 5) Myalgia/arthralgia
 - 6) Urticaria
 - 7) Vasomotor symptoms: hypotension, hypertension, flushing, tachycardia, and nausea/vomiting
 - 8) Anaphylaxis
 - 9) Aseptic meningitis
 - 10) Thrombotic events
2. Subcutaneous infusion
 - a. Low incidence of systemic effects due to the slow equilibration of Ig into the circulation

- b. High incidence of local site reactions at infusion site
 - 1) Swelling
 - 2) Erythema
 - 3) Burning or itching sensation
- c. Site reactions resolve completely within 24 hours after the infusion is finished



VI. Preadministration Considerations

A. Patient Assessment

1. Initial assessment: prior to start of first infusion, obtain baseline information and screen patients for risk factors
 - a. Past medical history
 - 1) Cancer or malignancies
 - 2) Cardiac or pulmonary problems
 - 3) Neurological disorders
 - 4) Hepatic disorders
 - 5) Blood dyscrasias or hematologic disorders
 - 6) Diabetes
 - 7) Hypertension
 - 8) Serious viral, fungal, or bacterial infections
 - a) For patients receiving TNF inhibitors, screen for history of tuberculosis, histoplasmosis, and coccidiomycosis
 - b) Screen patient for active infections
 - 9) Hepatitis C screening
 - 10) TB testing results
 - b. Medication/allergy profile
 - 1) Obtain current medication list
 - a) Review for possible interactions or contraindications with concurrent medications
 - 2) Obtain allergies/sensitivities to food/drugs
 - 3) Assess the history of prior treatments with biologic agents or Ig
2. Ongoing assessment (prior to each infusion)
 - a. Current health status
 - 1) Weight
 - 2) Vital signs
 - 3) Hydration status
 - 4) Skin integrity
 - 5) General appearance
 - 6) Symptoms of active current infection
 - b. Laboratory results
 - 1) CBC with differential
 - 2) Platelet count
 - 3) PT/PTT
 - 4) Liver and kidney function tests
 - 5) C-reactive protein
 - 6) Chest X-ray, if ordered
 - c. Patient's response to treatment
 - 1) Assess the response or lack of response to treatment
 - 2) Patient self-assessment tools
 - a) Health Assessment Questionnaire (HAQ)
 - b) Inflammatory Bowel Disease Questionnaire

B. Patient/Caregiver Education

1. Provide and discuss the following information with the patient/caregiver
 - a. Purpose of the therapy
 - b. Treatment schedule
 - c. Potential adverse/side effects of the therapy
 - d. Cost/reimbursement
 - e. Expectations from the therapy
2. Provide instructions for patients who self-administer subcutaneous injections
 - a. How to prepare medication
 - b. Identification of subcutaneous sites
 - c. Injection into subcutaneous tissue
 - d. Rotation of injection sites
 - e. Signs and symptoms
 - f. What to do when dose is missed or skipped

C. Drug Preparation and Handling

1. Preparation: dosage and drug reconstitution
 - a. Dose based on patient's weight
 - b. Biologic agents available in protein powder preparation must be handled properly to avoid destabilization of the protein
 - c. Avoid vigorous agitation of Ig products as this can denature the Ig protein
2. Handling: biologic agents and IgIV products are not considered hazardous or cytotoxic



VII. Complications/Adverse Reactions

A. Infusion Reactions Associated with Biologic Agents

1. Exact mechanism and cause of infusion reactions related to biologic agents are unknown
2. Studies suggest that the reaction may not be IgE-mediated
3. Acute reactions
 - a. Occur within 1 to 2 hours of an infusion
 - b. Common symptoms
 - 1) Dizziness
 - 2) Headaches
 - 3) Chest tightness
 - 4) Rash
 - 5) Hypotension
4. Delayed reactions
 - a. Occur up to 14 days after treatment
 - b. Common symptoms
 - 1) Arthralgia
 - 2) Myalgia
 - 3) Malaise
 - 4) Fever
 - 5) Urticarial rash
 - 6) Fatigue
 - 7) GI symptoms

5. Treatment, management, and prevention
 - a. In the event of an infusion reaction
 - 1) Stop the infusion of the biologic agent
 - 2) Infuse 0.9% sodium chloride
 - 3) Administer medication as ordered
 - a) Antihistamine
 - b) Corticosteroids
 - c) Acetaminophen
 - 4) Observe patient for symptom resolution
 - 5) Notify the LIP
 - 6) Consider readministration of the biologic agent to complete infusion
 - b. Prevention of potential infusion reaction
 - 1) Pre-medicate prior to infusion (prophylaxis)
 - a) Antihistamine
 - b) Acetaminophen
 - c) Corticosteroids
 - d) H₂ antagonists

B. Infusion Reactions Associated with IgIV Therapy

1. Anaphylactoid reactions
 - a. Chills/rigors
 - b. Headache/migraine headache
 - c. Malaise/flu-like symptoms
 - d. Myalgia/arthritis
2. Allergic reactions
 - a. Urticaria
 - b. Vasomotor symptoms
 - 1) Hypotension/hypertension
 - 2) Flushing
 - 3) Tachycardia
 - 4) Nausea/vomiting
3. Other adverse reactions
 - a. Back pain/hip pain/arthritis
 - b. Anaphylaxis
 - 1) Hypotension
 - 2) Strong uncomfortable feeling
 - 3) Tightening in and around the neck, chest, and abdomen
 - 4) Difficulty swallowing
 - 5) Choking sensation/difficulty breathing
 - 6) Wheezing
 - 7) Rash or hives
 - 8) Rapid or weak pulse
 - 9) Sweating
 - 10) Upset stomach with or without vomiting and diarrhea
 - c. Aseptic meningitis
 - 1) Severe headache with nuchal rigidity
 - 2) Drowsiness
 - 3) Fever
 - 4) Lethargy
 - d. Thrombotic events

4. Treatment and management
 - a. In the event of an infusion reaction
 - 1) Stop the IgIV infusion
 - 2) Infuse 0.9% sodium chloride
 - 3) Administer medications as ordered
 - a) Antihistamines
 - b) Corticosteroids
 - c) Acetaminophen
 - d) Ibuprofen or NSAIDs
 - e) Epinephrine as needed
 - 4) Observe patient for symptom resolution
 - 5) Notify the LIP
 - 6) Consider continuation of infusion as ordered

BIBLIOGRAPHY

- Abatacept (Orencia) prescribing information, Bristol Myers Squibb, Princeton, NJ, December 2011.
- Adalimumab (Humira) prescribing information, Abbott Laboratories, North Chicago, IL, December 2011.
- Anakinra (Kineret) prescribing information, Amgen, Thousand Oaks, CA, December 2009.
- Certolizumab pegol (Cimzia) prescribing information, UCB, Smyrna, GA, September 2011.
- Chernecky, C., & Berger, B. (2013). *Laboratory tests and diagnostic procedures* (6th ed.). St. Louis, MO: Elsevier/Saunders.
- Clinical Trials.gov. Retrieved from <http://clinicaltrials.gov>.
- Eaton, L., & Tipton, J. (Eds.). (2009). *Putting evidence into practice: Improving oncology patient outcomes*. Pittsburgh, PA: Oncology Nursing Society.
- Etanercept (Enbrel) prescribing information, Amgen/Pfizer/Immunex Thousand Oaks, CA, December 2011.
- Gahart, B., & Nazareno, A. (2012). *2012 Intravenous Medications: A handbook for nurses and health professionals* (28th ed.). St. Louis, MO: Elsevier Health Sciences.
- Gardasil. (2012). *Merck & Co.*, Whitehouse, NJ. Retrieved from www.gardasil.com/.
- Golimumab (Simponi) prescribing information, Janssen Biotech, Inc., Horsham, PA, August 2011.
- Infliximab (Remicade) prescribing information, Janssen Biotech, Inc., Horsham, PA, October 2011.
- Infusion Nurses Society. (2011). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S1–S110.
- Immune Deficiency Foundation. (2011). *Immunoglobulin product chart*. Retrieved from <http://primaryimmune.org/wp-content/uploads/2011/11/Ig-Therapy-Chart-rv-10.11.pdf>.
- McCauley, D. (2012). *Laboratory values*. Retrieved from <http://www.globalrph.com/labs.htm>.
- Natalizumab (Tysabri) prescribing information, Biogen Idec Cambridge, MA, January 2012.
- National Institute of Arthritis and Musculoskeletal and Skin Diseases (2010). *Understanding autoimmune diseases*. Retrieved from http://www.niams.nih.gov/health_info/Autoimmune/.
- National Institute of Health. Retrieved from <http://www.cancer.gov/cancertopics/factsheet/information/clinical-trials>.
- Newton, S., Hickey, M., & Marrs, J. (2009). *Mosby's oncology nursing advisor. A comprehensive guide to clinical practice*. St. Louis, MO: Mosby Elsevier.
- Polovich, M., Whitford, J., & Olsen, M. (2009). *Chemotherapy and biotherapy guidelines and recommendations for practice* (3rd ed.). Pittsburgh, PA: Oncology Nursing Society.
- Procrit. Retrieved from www.procrit.com/.
- Rituximab (Rituxan) prescribing information, Biogen Idec/Genentech, San Francisco, CA, April 2011.
- Schulmeister, L. (2010). Antineoplastic therapy. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.). *Infusion nursing: An evidence-based approach* (3rd ed., pp. 351–371). St. Louis, MO: Saunders/Elsevier.
- Torisel. Retrieved from www.torisel.com/.
- Ustekinumab (Stelara) prescribing information, Janssen Biotech, Inc., Horsham, PA, August 2011.
- Vizcarra, C. (2010) Biologic therapy. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.). *Infusion nursing: An evidence-based approach* (3rd ed., pp. 299–315). St. Louis, MO: Saunders/Elsevier.
- Vizcarra, C., & Belcher, D. (2006). Management of the patient receiving parenteral biologic therapy. *Journal of Infusion Nursing*, 29(2), 63–71.
- Wilkes, G., & Barton-Burke, M. (2011). *Oncology nursing drug handbook*. Sudbury, MA: Jones and Bartlett.
- Yarbro, C. H., Wujcik, D., & Gobel, B. H. (2011). *Cancer nursing: Principles and practice* (7th ed.). Sudbury, MA: Jones and Bartlett.

Parenteral Nutrition

Elizabeth Krzywda, MSN, APNP

Doug Meyer, RPh, MBA, BCNSP



I. Overview

A. Definition

1. The provision of nutrients through the venous system
2. In the past, intravenous nutrition was referred to as TPN (total parenteral nutrition) or even hyperalimentation, but the current term is parenteral nutrition or PN

B. Goals

1. To provide all essential nutrients in adequate amounts to sustain nutritional balance during periods when oral or enteral routes of feedings are not possible or are insufficient to meet the patient's nutrient needs
2. To preserve or restore the body's protein metabolism and prevent the development of protein or caloric malnutrition
3. To replace nutritional deficits

C. Types

1. Peripheral parenteral nutrition (PPN)
 - a. A nutritional solution that involves the infusion of low osmolarity dextrose, amino acids, fat, electrolytes, vitamins, and trace elements using the peripheral intravenous route
 - b. This form of nutritional therapy may only provide partial nutritional requirements and thus is used for short-term or supplemental nutritional support
2. Central PN
 - a. The infusion of high concentrations of dextrose, amino acid, fat, electrolytes, vitamins, and trace elements via a central vein
 - b. This form of nutritional therapy provides sufficient nutrients to satisfy total nutritional requirements

D. Considerations for Evaluating the Need for PN

1. Patients who are candidates for PN support cannot, should not, or will not eat adequately to maintain their nutrient stores via the gastrointestinal route; these patients are already or have the potential of becoming malnourished
2. Any patient unable to digest sufficient nutrients via the gastrointestinal tract is a potential candidate for PN
3. The least invasive, least expensive means of supporting a patient's nutritional status must be considered
4. The gastrointestinal route should always be used if appropriate
 - a. Serious adverse effects can be associated with a totally resting gastrointestinal tract
 - b. Enteral nutrition preserves intestinal mass and structures, as well as hormonal, enzymatic, and immunologic function better than does intravenous nutrition
5. Nutritional risk or deficit should be assessed when evaluating a patient for PN
6. Generally, nourished patients unable to eat for as long as 7 to 10 days do not require PN; however, PN should be considered after 7 days with insufficient enteral intake
7. The indications and disease states for which PN are clearly beneficial are continually being established and reassessed



II. Indications

A. Before initiation of PN, the decision to use PPN versus central PN is determined by the extent of nutritional depletion, duration of illness, and clinical course

B. PPN

1. Indications
 - a. Used to provide partial or total nutritional support in patients who cannot absorb and digest oral or enteral tube-delivered nutrients, or when central PN is not feasible
 - b. Used in patients who cannot be fed by the oral or enteral route, requiring nutritional support by the parenteral route for anticipated therapy of 7 to 10 days
 - c. Used as supplemental nutritional support to oral or enteral nutrition or as a transition to enteral nutrition
 - d. Used as transitional support until PN can be initiated or resumed
 - e. Used in patients for whom central venous access is either impossible or contraindicated
2. Specific pediatric indications
 - a. Indications are similar to those for adults
 - 1) PPN is suggested for nonstressed infants for brief courses of maintenance therapy when full growth and development are not the primary goal
 - 2) Central PN is a more logical choice for supporting normal growth and maintaining body composition

- b. Generally used for nutrition support for a short time (as long as 2 weeks) because of limited access to peripheral veins: in older infants and children, nutrition repletion or aggressive nutrition support may be possible by this route, except in patients requiring fluid restriction
- 3. Contraindications
 - a. Long-term support is needed
 - b. Poor or inaccessible peripheral venous access
 - c. Severe malnourished state
 - d. Large volumes of fluid cannot be tolerated
 - e. Nutrient needs are greater than what can be safely met with PPN
 - f. Functional gastrointestinal tract
 - g. Refusal by patient or legal guardian

C. Central PN

- 1. Indications
 - a. Necessary when parenteral feeding is indicated for longer than 2 weeks, peripheral venous access is limited, nutrient needs are large, or fluid restriction is required and the benefits of PN support outweigh the risks
 - b. Used for patients requiring intravenous nutrition as the primary or supportive therapy
 - 1) PN is frequently indicated for patients with disease states that result in impaired ability to digest nutrients by the oral or enteral routes in quantities sufficient to satisfy nutritional requirements
 - c. Used in disease states in which the use of PN may be indicated as a primary therapy
 - 1) Short gut syndrome
 - 2) Enterocutaneous fistula
 - 3) Selected cases of allogenic bone marrow transplant, acute exacerbation of Crohn's disease, severe necrotizing pancreatitis, and intractable nausea with vomiting
 - 4) Prolonged ileus or distal obstruction
 - d. There are other disease states in which PN may be indicated as supportive therapy or conditions in which the efficacy of PN has not been clearly demonstrated (e.g., inflammatory bowel disease, anorexia nervosa)
 - e. The use of PN for cancer support, sepsis, trauma, and general perioperative support may be appropriate in selected situations
- 2. Specific pediatric indications
 - a. Disease states that affect the pediatric populations as outlined for adult
 - b. Extremely premature infant
 - c. Disorders of the respiratory system
 - d. Disorders of the gastrointestinal tract
 - 1) Congenital anomalies
 - 2) Surgical conditions
 - 3) Intractable diarrhea of infancy
 - 4) Inflammatory conditions
 - 5) Neuromuscular disorders
 - e. Hypercatabolic states
- 3. Contraindications
 - a. Functional gastrointestinal tract
 - b. Sole dependence on PN is clearly <5 days

- c. Inability to obtain central venous access
- d. Prognosis does not warrant aggressive nutritional support
- e. Refusal by patient or legal guardian
- f. Risks of PN outweigh its benefits
- g. Minimal stress and trauma or the immediate postoperative or poststress periods in a well-nourished patient when it is anticipated that convalescence will be short and the gastrointestinal tract can be used within 7 to 10 days
- h. Malnutrition caused by a rapidly progressive disease not amenable to curative or palliative therapy; disease is proven or suspected of being untreatable



III. Nutrient Balance and Malnutrition

A. Nutrient Balance

1. Nutrients: constituents in food that supply the body with its necessary elements
 - a. Certain nutrients (carbohydrates, fats, proteins, and alcohol) provide energy
 - b. Other nutrients (water, electrolytes, minerals, and vitamins) are essential to the metabolic process
2. Nutritional status
 - a. The condition of the body resulting from the utilization of the essential nutrients available to the body
 - b. Nutritional status depends on the quality and quantity of nutrients consumed, the relative need for nutrients, and the ability of the body to use nutrients
3. Nutritional deficiency
 - a. Occurs when adequate amounts of essential nutrients required for proper functioning are not provided to the body tissues; may be primary or secondary
 - b. Primary deficiency occurs when the diet is deficient in a particular nutrient or nutrients
 - c. Secondary deficiency results from impairment in normal digestion, absorption, and use of essential nutrients, resulting in nutrient deficiency; this may occur despite adequate ingestion or metabolic stress

B. Malnutrition

1. Classification
 - a. Patients should be considered malnourished or at risk for malnutrition if they have inadequate nutrient intake for ≥ 7 days or if they have weight loss $\geq 10\%$ of their body weight within 6 months or $> 5\%$ in 1 month
 - b. The most common causes of malnutrition are protein and calorie deficiencies
 - c. Three types of protein-calorie malnutrition have been identified: marasmus, kwashiorkor, and marasmus-kwashiorkor; it is important to determine the nature and severity of protein-calorie depletion so that appropriate nutritional support can be given

2. Marasmus—simple starvation
 - a. Characteristics
 - 1) A gradual wasting of adipose and somatic muscle with preservation of visceral proteins; the patient is cachectic
 - 2) Chronic condition in which basal metabolic rate (BMR) is reduced; fat is the major energy substrate, and visceral proteins are preserved
 - 3) Presents with weight loss, adipose and skeletal muscle atrophy, decreased anthropometric measurements, and development of immune incompetence, which is accompanied by decreased total lymphocyte counts and skin test energy
 - b. Causes
 - 1) Occurs when there is an acceptable ratio of protein–caloric intake but inadequate total dietary intake
 - 2) Seen with prolonged starvation, anorexia, chronic illness, old age
 - c. Goal of therapy: to restore fat and protein stores over a prolonged period
3. Kwashiorkor—protein dysmetabolism or hypoalbuminemia
 - a. Characteristics
 - 1) Presents with increase in extracellular water spaces, pitting edema, salt retention, occasionally ascites, and anasarca
 - 2) Visceral protein stores are depleted, with depressed concentrations of serum albumin, transferrin, thyroxin-binding prealbumin, and retinol-binding protein
 - 3) Immunocompetence is impaired, and the patient is susceptible to infection
 - b. Causes
 - 1) Caloric intake is adequate or excessive, but diet consists of almost all carbohydrates with little or no protein
 - 2) Seen during periods of decreased protein intake accompanied by increased carbohydrate intake (e.g. liquid diets, fad diets, long-term use of intravenous fluids containing dextrose)
 - c. Goal of therapy: to preserve the remaining protein stores
4. Marasmus-kwashiorkor
 - a. Characteristics
 - 1) Presents with skeletal muscle and visceral protein wasting, depleted fat stores, immune incompetence; individuals appear cachectic, and are usually undergoing acute catabolic stress; can also present with vitamin and mineral deficiencies
 - 2) Associated with the highest risk of morbidity and mortality
 - b. Causes
 - 1) Individuals share some aspect of both marasmus and kwashiorkor
 - 2) Two phases of abnormal dietary intake occur: initial reduced protein intake with subsequent decreased total intake or vice versa
 - 3) May occur in hospitalized patients with pre-existing marasmus complicated by hospital-induced kwashiorkor resulting from administration of intravenous dextrose solutions or metabolic stress imposed on an individual with pre-existing malnutrition
 - c. Goal of therapy: restore protein and fat stores



IV. Nutritional Requirements

A. Determination of Nutrient Requirements

1. The requirement for a nutrient is the minimum intake that will maintain normal function and health
2. The United States standard for determining nutrient intake and diet evaluation dates back to 1941 and the establishment of the Recommended Daily Allowance or RDA. Since 1995, a joint effort by the US and Canada has lead to a single set of references now known as the Dietary Reference Intakes or DRI. These reference intakes address the needs of healthy individuals as opposed to those with disease. DRI are divided into four categories:
 - a. Estimated average requirement or EAR: estimated to meet the requirements of half of healthy individuals in a particular group (gender and age)
 - b. RDA: recommended daily allowance that meets the needs of all individuals
 - c. Adequate intake or AI: average intake of a group that seems to sustain a defined nutrient state
 - d. Tolerable upper intake level or UL: the maximum intake that is unlikely to pose a health problem

B. Energy Balance

1. Positive balance exists when food intake exceeds expenditure; excess energy is stored primarily as fat, and weight gain results
2. Negative balance exists when energy expenditure exceeds food intake; weight loss results as the body uses its own energy stores to meet the requirements
3. Equilibrium exists when energy in food equals energy expended; body weight remains constant

C. Energy Requirements

1. Energy requirements are dependent on a number of factors, which include the body surface area (derived from height and weight), age, and gender; they are usually estimated from tables or from simple formulas
2. Energy expenditure
 - a. Total daily energy (TDE) expenditure has three components:
 - 1) Basal energy expenditure (BEE) or basal metabolic rate (BMR)
 - 2) Energy expenditure is related to activity
 - 3) Specific dynamic action (SDA) of food
 - b. Determination of energy needs can be determined from the BEE or resting metabolic expenditure (RME); BEE is the amount of energy produced per unit of time under "basal" conditions; RME is the amount of energy expended at any time other than during basal conditions but with the patient at thermal neutrality
 - 1) The terms BEE and RME frequently are used interchangeably; however, RME is usually approximately 10% higher than BEE in healthy persons
 - 2) BEE accounts for 65% to 75% of energy expenditure and may be measured or estimated

- 3) The traditional method used to estimate BEE is the Harris-Benedict equation, which takes into consideration the patient's weight in kilograms, height in centimeters, age, and gender
 - For men: $\text{BEE (kcal/day)} = 66 + (13.7 \times \text{weight [kg]}) + (5.0 \times \text{height [cm]}) - (6.8 \times \text{age})$
 - For women: $\text{BEE (kcal/day)} = 65.5 + (9.6 \times \text{weight [kg]}) + (1.8 \times \text{height [cm]}) - (4.7 \times \text{age})$
- 4) May be modified for activity factors (AF) and injury factors (IF)
 - $\text{TDE} = (\text{BEE}) (\text{AF}) (\text{IF})$
 - AF: confined to bed = 1.2; out of bed = 1.3
 - IF: surgery = 1.1 to 1.2; infection = 1.2 to 1.6; trauma = 1.35 to 1.6; burns = 1.5 to 1.9
- 5) A simpler, widely accepted method used to estimate daily adult caloric requirements is to use 20 to 35 calories/kg/day
- 6) Two methods are available to measure the BMR: direct or indirect calorimetry; the term calorimetry derives from heat metabolism
 - Direct calorimetry methods directly measure heat produced by the body; this technique is cumbersome, expensive, and difficult to apply to acutely ill or injured patients
 - Indirect calorimetry indirectly measures the heat production of the body through measurement of oxygen consumption and carbon dioxide production; it is the most accurate method of determining caloric requirements
- c. Energy expenditure of activity: the second largest component of daily energy expenditure. Energy requirement can vary from 1.1 to 10.3 kcal/kg/hour, depending on the type of activity
- d. SDA of food: the increased heat production that occurs with food ingestion or infusion of parenteral nutrients: add 10% to the sum of BMR plus energy expenditure of activity to account for SDA

D. Protein

1. Classifications
 - a. Amino acids are the basic units of protein; there are essential and nonessential amino acids
 - 1) Essential amino acids cannot be synthesized in the body and must be received in the diet
 - 2) Nonessential amino acids can be synthesized by the body
 - 3) Conditionally essential amino acids are nonessential under normal circumstances but are required in the diet during certain disease states because use exceeds synthesis
 - b. The amino acids are also classified as aromatic amino acids (AAA) or branched-chain amino acids (BCAA)
 - 1) BCAAs are oxidized principally by skeletal muscle
 - 2) The rate of oxidation of BCAAs in muscle is stimulated by stress, fasting conditions associated with muscle protein wasting, and negative nitrogen balance
 - c. Essential amino acids: isoleucine (BCAA), leucine (BCAA), lysine (AAA), methionine (AAA), phenylalanine (AAA), threonine (AAA), tryptophan (AAA), valine (BCAA)
 - d. Conditionally essential amino acids: histidine, cysteine, tyrosine, arginine, glutamine

- e. Nonessential amino acids: alanine, aspartic acid, asparagine, glutamic acid, glycine, proline, serine
- 2. Function
 - a. The major function of protein is contributing to tissue growth, repair, and replacement of all body cells
 - b. Proteins are components of the body's defense mechanism and are found in antibodies, scar tissue, and clots; the body's functional molecules (enzymes, hormones, and carrier substances) require protein for development
 - c. Although protein can contribute to energy needs (approximately 4 kcal/g), this is not its major purpose
- 3. Metabolism
 - a. Body protein is constantly being turned over by the process of synthesis and catabolism, with approximately 40% of the body's resting energy expenditure used for these processes
 - 1) During periods of inadequate nutrient intake, mobilization and catabolism (breakdown) of the body's protein compartment occur to supply energy substrate as glucose
 - 2) A positive balance of calories and nitrogen is needed to promote anabolism (build-up)
 - b. There is no storage form of amino acids other than the body muscle mass
 - c. The amino acids released as a result of skeletal muscle catabolism are the main sources of nitrogen, which is released in the urine as urea
 - d. Factors regulating the rate of metabolism, such as extreme environmental stress, infection, fever, trauma, and surgical procedures, can result in substantial urinary loss of nitrogen
 - 1) In illness or trauma that has led to severe protein depletion, protein requirements for repletion of wasted tissues are increased; this is similar to the process that occurs in infants and children who are in a state of rapid growth
 - 2) The degree of stress, possible hypercatabolic state, and special clinical conditions such as renal failure and hepatic insufficiency affects protein need and tolerance
- 4. Protein compartments: the body's protein resides in two compartments
 - a. Somatic compartment: includes skeletal muscle, skeleton, and skin-supporting structure
 - b. Visceral compartment: includes solid viscera and secretory proteins
- 5. Requirements
 - a. Protein needs are determined according to the results of nitrogen balance studies
 - 1) Predicted protein requirements are equated with the lowest quantity of protein needed to maintain health and nitrogen equilibrium
 - 2) An important objective is to maintain a positive nitrogen balance
 - b. Requirement is dependent on a number of metabolic factors, such as the previous nutritional status, degree of nutritional depletion, provision of nonprotein energy, and the rate of desired repletion. Requirements increase in certain states (athletic training, growth, and pregnancy) or in catabolic states (stress and trauma)
 - c. Providing nonprotein calories to meet the energy needs will promote nitrogen retention
 - d. 1 g nitrogen is equal to 6.25 g of protein

- e. Effective nitrogen supplementation during PN is based on the following requirements for the adult patient:
 - 1) Maintenance: 0.8 to 1.0 g/kg/day
 - 2) Catabolic patients: 1.2 to 2.0 g/kg/day
 - 3) Chronic renal failure: 1.5 to 1.8 g/kg/day
 - 4) Acute renal failure and catabolic state: 1.5 to 1.8 g/kg/day
 - 5) Critically ill patients: 2.0 g/kg/day may be required
- f. Pediatrics
 - 1) Child older than 12 months: 1.0 to 1.6 g/kg/day
 - 2) Infants: 1.6 to 2.2 g/kg/day

E. Carbohydrates

1. Definition: organic compounds composed of carbon, hydrogen, and oxygen
2. Serve as the major source of energy in humans
3. Types
 - a. Dextrose (glucose)
 - 1) Is the primary source of carbohydrate calories in PN solutions
 - 2) Is a physiologic substrate, easily purified for intravenous administration, inexpensive, and can be provided in high concentrations
 - 3) 1 g dextrose provides approximately 3.4 calories
 - b. Fructose
 - 1) Naturally occurring monosaccharide that offers an alternative to dextrose as a source of carbohydrate calories
 - 2) Fructose does not require insulin for conversion to glucose; however, most adult tissues cannot use fructose directly and require its conversion to glucose in the liver
 - 3) Hyperglycemia and glycosuria occur less frequently with fructose than with corresponding amounts of glucose
 - 4) Rapid infusion of fructose has been associated with lactic acidosis, hypophosphatemia, elevated serum bilirubin and uric acid levels, and depletion of hepatic adenine nucleotides
 - c. Sorbitol and xylitol
 - 1) Alcohol sugars that are only partially insulin independent
 - 2) Both require conversion to glucose in the liver and are associated with numerous toxic effects, including lactic acidosis, hepatic failure, and hyperuricemia
 - d. Glycerol
 - 1) Naturally occurring sugar alcohol that provides 4.3 calories/g
 - 2) The use of glycerol as an exclusive energy source is relatively recent and requires further clinical investigation
4. Functions
 - a. Major function is as an energy-providing nutrient
 - b. Carbohydrate is protein sparing; when the body does not receive sufficient energy calories it will turn to breaking down protein and fat stores for energy
5. Metabolism
 - a. When glucose is supplied as a nutrient, the quantity not immediately used for energy calories is stored in the liver and muscle as glycogen
 - 1) Glycogen is the storage form of glucose
 - 2) When glycogen storage capacity is exhausted, excess carbohydrate is stored as fat

- b. Carbohydrate metabolism, like all forms of metabolism, has a constructive phase called anabolism and a destructive phase called catabolism
 - 1) The three major processes involved in carbohydrate catabolism are glycolysis (initial process in which sugar is broken down into simpler compounds), the Krebs cycle (completed carbohydrate catabolism), and glycogenolysis (conversion of glycogen stores into glucose)
 - 2) The two major processes involved in carbohydrate anabolism include glycogenesis (glucose converted to glycogen) and gluconeogenesis (transformation of fats and proteins into glucose or glycogen for use by cells for fuel)
 - c. Rate of glucose metabolism varies between 0.4 and 1.4 g/kg/hour; maximum glucose use rate is approximately 5 mg/kg/minute. Overfeeding by supplying glucose in excess of this rate does not further accentuate nitrogen retention and produces adverse effects such as fatty liver and increased carbon dioxide production, which may aggravate pre-existing respiratory distress
6. Requirements
- a. There is no specific requirement for carbohydrates
 - 1) Individual requirements are determined by estimating or measuring energy requirements
 - 2) It can be synthesized from amino acids and glycerol by gluconeogenesis, although it is preferable to ingest carbohydrates
 - b. Carbohydrates are generally used to provide at least 50% of total calories

F. Fat

- 1. Definition: biologic substance soluble in organic solvents and insoluble in water
- 2. Types
 - a. Essential fatty acids
 - 1) Linoleic acid is the primary essential fatty acid required for growth
 - 2) Linolenic acid may not be essential for adults, but it may be essential for proper visual and neural development and in certain disease states
 - b. Major lipid substances within the body include triglycerides, phospholipids, cholesterol, and fatty acids
- 3. Functions
 - a. Responsible for a wide range of metabolic and structural functions
 - b. Essential for structural integrity of cell membranes and is necessary for absorption of fat-soluble vitamins
 - c. In PN, lipids are a major source of metabolic fuel and a source of essential fatty acids
- 4. Metabolism
 - a. The most concentrated source of heat and energy, providing more than twice as many energy calories per gram (9 kcal/g) as either protein or carbohydrates; fat stores are a reserve of body energy that is mobilized when necessary
 - b. Lipids are isotonic and can be infused in peripheral veins
 - c. Allows a decrease in the concomitant intake of glucose and a reduction in the complications associated with large glucose loads in critically ill patients
 - d. There are lower levels of circulating insulin in lipid-containing PN preparations

5. Requirements

- a. The main purpose of intravenous fat is to prevent the onset of essential fatty acid deficiency (EFAD), manifested as dermatitis, hemolytic anemia, thrombocytopenia, impaired wound healing, and hepatic dysfunction secondary to fatty metamorphosis
- b. There is no recommended dietary allowance for fat as a nutrient in the diet; EFAD can occur in as little as 5 days without fat supplementation
- c. The minimum human requirement needed to prevent EFAD should represent 2% to 4% of the total caloric intake
- d. The optimum dose of lipid for the provision of calories is not known
 - 1) Most patients receive 10% to 40% of the daily caloric intake, 2.5 g/kg for adults or 4 g/kg for pediatric patients
 - 2) The standard distribution of nonprotein calories is 70% to 85% as carbohydrates and 15% to 30% as fat. There is limited clinical benefit when the fat content exceeds 30% of nonprotein calories in PN

G. Fluid

1. Requirements

- a. Maintenance: 30 to 35 mL/kg/day or 1,500 mL for the first 20 kg plus 20 mL/kg for actual weight beyond 20 kg
- b. Factors increasing requirements: extraordinary exogenous losses (e.g., fistulas, diarrhea, nasogastric tube drainage)

2. Fluid changes induced by starvation

- a. Extracellular fluid (ECF)
 - 1) Most of early water loss in starvation originates from ECF
 - 2) If fasting continues, loss of ECF is markedly reduced
 - 3) Water and sodium are conserved, and catabolism of body cell mass results in a proportionally high extracellular water content
- b. Intracellular fluid
 - 1) Oxidation of cell substrates results in net production of free water
 - 2) Water normally bound to macromolecules, such as glycogen and protein, is free to diffuse to the ECF

3. Fluid changes induced by acute injury

- a. Acute injury is followed by characteristic fluid and electrolyte distortions that tend to maintain plasma volume and tissue perfusion
- b. Sodium and water retention occurs along with the formation of third spaces in injured areas or in the gastrointestinal tract

4. Fluid changes induced by PN

- a. Fluid overload can occur if PN is administered with a predetermined number of calories without regard for the volume infused
- b. To prevent fluid overload, the concentration of glucose calories can be increased, or fat needs to be added as a caloric source

H. Essential Macronutrients (Electrolytes)

1. Considerations

- a. The following factors should be considered when determining the electrolyte requirements for a patient receiving PN:
 - 1) Pre-existing electrolyte deficits
 - 2) Excessive fluid and electrolyte losses

- 3) Daily electrolyte needs
 - 4) End organ function, especially renal function
 - b. With protein–calorie malnutrition, there is loss of the intracellular ions, potassium, magnesium, and phosphorus, together with a gain in sodium and water
 - c. It is necessary to give potassium, magnesium, phosphorus, and zinc to ensure optimum nitrogen retention
2. Sodium
- a. Recommendations/requirements
 - 1) Daily needs range from 100 to 150 mEq (1 to 2 mEq/kg)
 - 2) Supplement to cover abnormal losses
 - b. Considerations related to PN
 - 1) Abnormalities of sodium commonly linked to fluid administration
 - 2) Serum sodium concentrations in the acute phase may not reflect actual body sodium, but rather hyper- or hypovolemic states
 - 3) Less sodium may be required in patients with renal or cardiovascular disease
3. Potassium
- a. Recommendations/requirements: daily needs range from 80 to 100 mEq (1 to 2 mEq/kg); an anabolic patient may require 150 to 200 mEq/day
 - b. Considerations related to PN
 - 1) Glucose infusions will increase the need for potassium
 - 2) Approximately 3 mEq are retained with each gram of nitrogen
4. Chloride
- a. Recommendations/requirements: add quantity similar to total sodium content
 - b. Considerations related to PN
 - 1) To prevent hyperchloremic metabolic acidosis, crystalline amino acid formulations are acetate-balanced, with acetate substituted as an anion, and chloride is maintained in a 1:1 ratio with sodium
 - 2) Hypochloremic metabolic acidosis remains a risk in patients undergoing sustained gastric losses
5. Phosphorus
- a. Recommendations/requirements
 - 1) 20 to 40 mmol/day
 - 2) Increases when glucose alone is given as a source of energy; this is partly because lipid emulsions have phospholipids that act as an additional source of phosphorus, and high insulin levels associated with the glucose system increase cellular uptake of phosphorus
 - b. Considerations related to PN
 - 1) Hypophosphatemia is commonly found during the initial phase of nutritional support in previously debilitated, malnourished patients.
 - 2) With refeeding, there is a redistribution of phosphate into muscle, which can induce hypophosphatemia; signs and symptoms include tremors, paresthesias, ataxia, decreased platelet and erythrocyte survival, impaired leukocyte function, and weakness. This has been termed refeeding syndrome
6. Calcium
- a. Recommendations/requirements: 10 to 15 mEq/day
 - b. Considerations related to PN
 - 1) Administration of large amounts of phosphate salts can contribute to a lowering of serum calcium levels

- 2) In contrast, administration of intravenous phosphate and acetate-balanced solutions has been shown to decrease hypercalciuria and may be beneficial in maintaining calcium stores in patients receiving long-term PN
 - 3) In malnourished patients, serum calcium levels may be low as a result of decreased levels of albumin to which half of calcium is bound, whereas ionized calcium levels remain normal
 - 4) Calcium (and phosphate) dosages that are added to PN may be limited due to the risk of precipitate formation
7. Magnesium
- a. Recommendations/requirements
 - 1) 8 to 20 mEq/day
 - 2) Additional amounts may be required to cover losses from gastrointestinal secretions
 - b. Considerations related to PN
 - 1) Inadequate replacement aggravated by high losses can lead to clinical syndrome of hypomagnesemia (muscle weakness, fatigue, convulsions, nystagmus [abnormal lateral eye movements])
 - 2) Renal potassium and phosphate losses are increased by hypomagnesemia

I. Essential Micronutrients (Trace Elements)

1. Definition
 - a. Trace elements are found in the body in minute amounts; dosage parameters to meet basic requirements are usually very small (in milligrams)
 - b. Each trace element is a single chemical and has an associated deficiency state; functions of trace elements are many, and often their actions are synergistic
2. Iron
 - a. Uses/function
 - 1) Predominant function is oxygen transport
 - 2) Lowered serum iron observed in malnourished patients may be secondary to defects in iron mobilization, rather than lowered whole body stores
 - 3) The body has a large capacity to store iron in usable nutritional reserves and has limited potential to excrete excesses
 - 4) There are potential problems associated with compatibility, bioavailability, and administration with PN solutions
 - b. Signs/symptoms of deficiency
 - 1) Pallor, fatigue, exertional dyspnea, tachycardia, headache, listlessness, paresthesias, glossitis, stomatitis, altered attention span, abnormal skin and nail formation, microcytic anemia
 - c. Recommendations/requirements
 - 1) Iron dextran is not routinely added to parenteral solutions, rather if required is provided as a separate infusion
3. Iodine
 - a. Uses/function: thyroid hormone synthesis
 - b. Signs/symptoms of deficiency: goiter, hypothyroidism
 - c. Recommendations/requirements: 50 to 500 mcg/day intravenous
4. Zinc
 - a. Uses/function: most abundant of all the trace elements; an integral part of many enzymes and enzyme cofactors; is necessary for RNA, DNA, and protein synthesis

- b. Signs/symptoms of deficiency: alopecia, scaling, pustular rash, periorbital and nasolabial dermatitis; diarrhea; mental depression/apathy; glucose intolerance; night blindness; impaired taste sensation, wound healing, and T-lymphocyte dysfunction
 - c. Recommendations/requirements: 2.5 to 4.0 mg/day intravenous; additional 2 mg for acute catabolic state, additional 12 mg/L for small bowel fluid loss, and additional 17.1 mg/kg for stool or ileostomy output
- 5. Copper
 - a. Uses/function
 - 1) Essential with iron for normal erythropoiesis
 - 2) Constituent of many oxidative enzymes, such as ceruloplasmin, cytochrome oxidase, monoamine oxidase, and tyrosinase
 - 3) Ceruloplasmin aids the oxidation of ferrous iron in tissue stores to the ferric form to enable it to be transported by transferrin
 - 4) Copper deficiency results in anemia with an iron deficiency picture
 - b. Signs/symptoms of deficiency: microcytic anemia, leukopenia, neutropenia, skin and hair depigmentation, skeletal demineralization, and hypothermia
 - c. Recommendations/requirements: 0.5 to 1.5 mg/day intravenous (withhold in jaundiced patients or in those with liver dysfunction)
- 6. Chromium
 - a. Uses/function: potentiates insulin reaction with tissue receptors; in its absence, insulin-resistant diabetes and neurologic changes have been noted during PN
 - b. Signs/symptoms of deficiency: insulin-resistant glucose intolerance, neurologic changes (neuropathy), elevated serum lipids
 - c. Recommendations/requirements
 - 1) 10 to 15 mcg/day intravenous
 - 2) 20 mcg/day intravenous in the presence of intestinal losses
- 7. Manganese
 - a. Uses/function
 - 1) Antioxidant protection and energy metabolism
 - 2) Formation of connective tissue
 - 3) Soluble cofactor in a number of enzymatic reactions
 - 4) Affects carbohydrate synthesis from pyruvate
 - b. Signs/symptoms of deficiency: extrapyramidal symptoms, bony abnormalities, central nervous system dysfunction, weight loss, transient dermatitis, occasional nausea and vomiting, changes in hair color
 - c. Recommendations/requirements: 0.15 to 0.80 mg/day intravenous
- 8. Selenium
 - a. Uses/function: catalyst for the enzyme glutathione peroxidase, an important antioxidant pathway
 - b. Signs/symptoms of deficiency: muscle dysfunction (including cardiac muscle changes), myalgias
 - c. Recommendations/requirements: 100 to 200 mcg/day intravenous
- 9. Molybdenum
 - a. Uses/function: cofactor for sulfite oxidase and xanthine oxidase
 - b. Signs/symptoms of deficiency: headache, night blindness, irritability, lethargy, coma
 - c. Recommendations/requirements: 150 to 500 mcg/day intravenous

J. Vitamins

1. Definition: vitamins are organic compounds necessary for normal growth and maintenance of the body but are required only in minute quantities; they cannot be synthesized by the body in sufficient amounts and thus must be provided in the diet
2. Properties/requirements
 - a. Act as cofactors for the operation of certain enzyme systems
 - b. The exact vitamin requirements for patients receiving PN are not known
 - c. Recommendations are typically based on estimations derived from the requirements of normal adults and adjusted for patients who have increased requirements as a result of illness, nutritional depletion, or stress
 - d. The composition of parenteral multivitamin preparations is based on recommendations established by the AMA Department of Food and Nutrition
3. Classifications
 - a. Fat soluble: vitamins A, D, E, and K
 - b. Water soluble: ascorbic acid (vitamin C) and the B complex vitamins: thiamine (B₁), riboflavin (B₂), niacin (B₃), pantothenic acid (B₅), pyridoxine (B₆), biotin (B₇), folic acid (B₉), and cyanocobalamin (B₁₂)
4. Factors that alter the status
 - a. Malnutrition, specific disease states, and drug therapy may predispose some patients to vitamin deficiencies
 - b. Continuous parenteral infusion of a multivitamin preparation is physiologically different from oral administration; the gut and liver play important roles in modifying and storing orally ingested vitamins
5. Vitamin A (retinols)
 - a. Uses/function
 - 1) Essential for the integrity of epithelial surfaces, synthesis of retinal pigments, and protection against infection
 - 2) Fat-soluble and stored in the liver
 - b. Signs/symptoms of deficiency: night blindness, xerophthalmia, mucosal keratinization
 - c. Recommendations/requirements: 3,300 International units (1 mg) daily intravenous
6. Vitamin D (calcitriol)
 - a. Uses/function
 - 1) Promotes intestinal calcium and phosphate absorption
 - 2) Mediates the mobilization of calcium from bone
 - b. Signs/symptoms of deficiency: bone pain and tenderness, proximal muscle weakness, skeletal deformity, low serum calcium and serum phosphate, elevated alkaline phosphate, tetany caused by hypocalcemia
 - c. Recommendations/requirements: 200 International units daily intravenous
7. Vitamin E (tocopherol)
 - a. Uses/function: acts as an antioxidant at the tissue level
 - b. Signs/symptoms of deficiency: edema, reticulocytosis, decreased erythrocyte survival time, excessive creatinuria, skeletal muscle lesions, increased platelet aggregation
 - c. Recommendations/requirements
 - 1) 10 International units daily intravenous
 - 2) A portion may come from lipid emulsions and a part from added vitamin

8. Vitamin K (phytonadione)
 - a. Uses/function: required for the synthesis of clotting factors II, VII, IX, and X
 - b. Signs/symptoms of deficiency: bleeding, prolonged prothrombin time, hematuria
 - c. Recommendations/requirements: 150 mcg/day intravenous (evaluate and monitor the use in the presence of anticoagulant therapy)
9. Thiamine (B₁)
 - a. Uses/function
 - 1) An integral part of the cocarboxylase enzyme complex, which is necessary for the metabolism of alpha-keto acids such as pyruvate
 - 2) Cells, such as neurons, that depend exclusively on carbohydrates as an energy substrate need thiamine
 - b. Signs/symptoms of deficiency: beriberi, peripheral neuropathy, Wernicke's encephalopathy, decreased or absent deep tendon reflex, muscle tenderness, muscle atrophy, fatigue, decreased attention span
 - c. Recommendations/requirements: 6 mg/day intravenous
10. Riboflavin (B₂)
 - a. Uses/function: coenzyme or active prosthetic group of flavoproteins involved with tissue oxidation and respiration
 - b. Signs/symptoms of deficiency: cheilosis, lip inflammation, oral fissures, seborrhea dermatitis, corneal vascularization, ocular disturbances
 - c. Recommendations/requirements: 3.6 mg/day intravenous
11. Niacin (B₃)
 - a. Uses/function: component of coenzymes nicotinamide adenosine dinucleotide (NAD) and NAD phosphate, which are essential for glycolysis, fat synthesis, and energy production
 - b. Signs/symptoms of deficiency: weakness, pellagra, diarrhea, tongue fissures, mental disorders, anorexia, oral inflammation, irritability
 - c. Recommendations/requirements: 40 mg/day intravenous
12. Pantothenic acid (B₅)
 - a. Uses/function: as part of coenzyme A, involved in the release of energy from carbohydrate synthesis of sterols, fatty acids, and steroid hormones
 - b. Signs/symptoms of deficiency: abdominal pain and cramps, headache, nausea/vomiting, lethargy
 - c. Recommendations/requirements: 15 mg/day intravenous
13. Pyridoxine (B₆)
 - a. Uses/function
 - 1) Cofactor for many amino acid-metabolizing systems
 - 2) Affects many neurotransmitters
 - 3) Required for the synthesis of heme proteins
 - b. Signs/symptoms of deficiency: central nervous system disorders, nasolabial seborrhea, glossitis, hypochromic microcytic anemia
 - c. Recommendations/requirements: 6 mg/day intravenous
14. Biotin (B₇)
 - a. Uses/function
 - 1) Essential cofactor for several enzymes
 - 2) Has direct and indirect effects on fatty acid synthesis, carbohydrate metabolism, and protein and nucleic acid synthesis
 - b. Signs/symptoms of deficiency: skin rash, alopecia, lethargy, depression, paresthesias, anemia, anorexia, nausea, muscle pain

- c. Recommendations/requirements
 - 1) 60 mcg/day intravenous
 - 2) 300 mcg/day intravenous for repletion
- 15. Folic acid (B_9)
 - a. Uses/function: transfer single carbon units as tetrahydrofolate
 - b. Signs/symptoms of deficiency: macrocytic anemia, diarrhea, stomatitis, glossitis, malabsorption
 - c. Recommendations/requirements: 0.4 to 1.0 mg/day intravenous
- 16. Cyanocobalamin (B_{12})
 - a. Uses/function: affects nucleic acid formation
 - b. Signs/symptoms of deficiency: megaloblastic anemia, glossitis, stomatitis, constipation, neuropathy
 - c. Recommendations/requirements: 5 mcg/day intravenous
- 17. Ascorbic acid (vitamin C)
 - a. Uses/function
 - 1) Affects the growth of fibroblasts, osteoblasts, and odontoblasts
 - 2) Plays a role in hydroxylation of proline and lysine
 - 3) Enhances absorption of iron and inhibits absorption of copper from the gastrointestinal tract
 - 4) Aids formation of active compounds from tetrahydrofolates
 - b. Signs/symptoms of deficiency: delayed wound healing, scurvy, hemorrhagic petechiae, gingivitis
 - c. Recommendations/requirements
 - 1) 200 mg/day intravenous
 - 2) 500 mg/day intravenous with catabolic stress



V. Disease States That Affect Nutritional Status

A. Diseases of the Esophagus and Stomach

- 1. Esophageal dysmotility and obstruction may inhibit nutrient ingestion
- 2. Gastric dysfunction: dysfunction of the stomach may cause nausea, vomiting, or an inability to ingest food orally or to pass on to the small intestine
- 3. Disorders of the stomach affecting nutrition
 - a. Delayed gastric emptying related to mechanical obstruction, diabetic gastroparesis, or surgery
 - b. Rapid gastric emptying (dumping syndrome) may result from gastric resection or vagotomy
 - c. Peptic ulcer disease
 - d. Gastric cancer

B. Diseases of the Intestine

- 1. Short bowel syndrome
 - a. Definition: the reduction of the absorptive surface of the intestine either as a result of surgery or disease that would jeopardize a person's survival from a nutritional standpoint
 - b. Virtually any nutrient, electrolyte, mineral, vitamin, or trace element deficiency can occur; nutritional alterations depend on site and length of resection, degree of adaptation, and existing disease

- c. Risk for malabsorption includes <200 cm of remaining small bowel, ileal resection, in addition to loss of large bowel
- d. Short bowel syndrome has three postoperative phases, and nutritional support needs to change as time allows adaptation of the bowel to proceed
 - 1) First phase is characterized by fluid and electrolyte loss caused by massive diarrhea
 - 2) Second phase is marked by eventual stabilization of the diarrhea and fluid and electrolyte requirements; in this period, adaptation occurs in the remaining bowel, although absorption deficiencies in fat, calcium, magnesium, and vitamins may persist
 - 3) Final phase is full adaptation, which may not be achieved by all patients; usually requires 3 to 12 months, diarrhea is controlled, and patients have improved tolerance of feedings
- 2. Inflammatory bowel disease
 - a. Describes two inflammatory intestinal conditions that affect nutrient intake and absorption: Crohn's disease and ulcerative colitis
 - b. Malnutrition is caused by several factors
 - 1) Decreased oral intake results from nausea and vomiting associated with the disease process; pain and cramping, which often increases with oral intake; and side effects of the medications used to treat the disease
 - 2) Excessive protein losses occur during acute diarrhea
 - 3) Malabsorption of vitamins and minerals almost always accompanies the disease process
 - c. Severe diarrhea can lead to varying degrees of dehydration and losses of sodium, potassium, chloride, and protein
 - d. Iron deficiency anemia is common
- 3. Pancreatitis
 - a. Almost all patients exhibit impaired carbohydrate metabolism, fluid and electrolyte imbalance, and hypoalbuminemia
 - b. Malabsorption causes weight loss, diarrhea, and steatorrhea
 - c. Pain, often severe and associated with anorexia and nausea, resulting in significant voluntary reduction in oral intake

C. Cardiac Failure

- 1. Malnutrition may precede or follow severe cardiac failure
- 2. Patients with cardiac failure frequently decrease their dietary intake because of anorexia, dietary restrictions, intestinal malabsorption, angina, gastrointestinal hypomotility, or digitalis intoxication
- 3. Patients have an elevated BMR
- 4. Malabsorption of neutral fats occurs with severe congestive heart failure
- 5. Sodium retention and potassium loss from diuretics may occur

D. Liver and Gallbladder Disease

- 1. Liver failure
 - a. Primary diseases of the liver include hepatitis and cirrhosis
 - b. Liver is the metabolic warehouse responsible for protein synthesis, excretion of bile required for digestion and absorption of fat, metabolism of toxins, and control of nutrients between fasting and fed states

- c. Metabolic changes include glucose intolerance, alteration in fat metabolism, protein intolerance, and an increase in nitrogen demand as a result of hepatocellular destruction
 - d. Impaired dietary intake from nausea, vomiting, anorexia, depression, lethargy, weakness, alcohol intake
 - e. Increased losses from vomiting, diarrhea, ascites, and steatorrhea
 - f. Decreased vitamin and mineral storage, decreased glycogenesis, glycogenolysis, gluconeogenesis, and decreased protein synthesis
2. Biliary tract obstruction
- a. Poor intake dependent on obstruction and gastrointestinal symptoms
 - b. Steatorrhea: malabsorption of fat as a result of a decrease in bile salts; decreased absorption of fat soluble vitamins secondary to fat malabsorption
 - c. Increased requirements for calories and protein secondary to possible fever and infection, postoperative stress

E. Renal Disease

1. Acute renal failure
- a. Poor intake as a result of anorexia, nausea, stomatitis, dry mucous membranes, alterations in taste perceptions, lethargy, possible impending coma
 - b. Increased losses secondary to vomiting, diarrhea; protein losses may occur during dialysis
 - c. Severe endogenous protein catabolism with accumulation of toxic protein metabolites and electrolyte imbalance
 - d. Increased nutritional substrates required to repair injured tissues; eliminate infections; and maintain hemodynamic, respiratory, and metabolic balances
 - e. Consider potassium and sodium content of medications
2. Chronic renal failure
- a. Poor intake secondary to anorexia, nausea, stomatitis, gum ulceration with bleeding, esophagitis, gastritis, and alterations in taste perception
 - b. Increased losses from vomiting and gastrointestinal bleeding; protein losses may occur during dialysis
 - c. Wasting of lean body tissue and muscle mass with concurrent fluid retention that may mask cachexia; increased nutrient substrates are required to repair injured tissues, eliminate infections, and maintain hemodynamic, respiratory, and metabolic balance

F. Diabetes Mellitus

- 1. Markedly elevated plasma glucose levels lead to glucosuria, which causes osmotic diuresis and urinary loss of calories, electrolytes, and water; prolonged periods of elevated blood sugars induce a hyperosmolar state and osmotic diuresis
- 2. Decreased peripheral glucose uptake, increased endogenous glucose productions, reduced suppression of glucose production with glucose infusion, and diminished capacity to oxidize infused glucose
- 3. Increased lipolysis, increased fat oxidation, and increased glycerol turnover
- 4. Increased protein breakdown, decreased protein synthesis, net body protein catabolism, decreased uptake of BCAAs by skeletal muscle, and increased amino acid efflux from skeletal muscle

G. Respiratory Diseases

1. Acute respiratory distress syndrome
 - a. Increases the risk of hypophosphatemia, which causes reduced oxygen transport
 - b. Drug nutrient reactions from bronchodilators, adrenergic agonists, antibiotics, and corticosteroids
2. Chronic obstructive pulmonary disease
 - a. Weight loss (24% to 26%) and malnutrition are common; degree of nutritional risk is estimated to be high when a patient with chronic obstructive pulmonary disease weighs <90% of ideal weight or has lost more than 15% of usual weight
 - b. Malnutrition is most likely related to an elevated energy expenditure secondary to increased work of breathing and deterioration of peripheral substrate metabolism during oxygen deficiency

H. Cancer

1. Severe malnutrition that occurs with cancer is called cancer cachexia
2. Anorexia is common and may be secondary to the tumor, depression, and cancer-related treatments
3. Depletion of host muscle and protein stores is common; abnormalities in protein metabolism include abnormal elevations in levels of whole body protein turnover and synthesis, elevated levels of whole body protein catabolism, and elevated levels of liver protein synthesis
4. Lipid abnormalities include elevated serum levels of lipids and marked depletion of host lipid reserves
5. Insulin resistance is a common finding in patients with cancer

I. Acquired Immune Deficiency Syndrome

1. Malnutrition can occur
2. Food intake may be diminished because of a variety of reasons; nutrient malabsorption as a result of intestinal injury may occur
3. Patients with chronic infections with fevers experience hypermetabolism or other metabolic derangements

J. Stress/Trauma/Burns

1. Stress
 - a. The metabolic response is a complex process mediated by the interaction of neurohormonal signals and increased production of cytokines, which creates severe nutritional-metabolic deficits in critically ill patients
 - b. Alteration in glucose metabolism includes hyperglycemia, insulin resistance, and increased resting energy expenditure
 - c. Protein needs increase
 - d. Lipolysis is increased during sepsis, and patients are more dependent on lipids for oxidation
2. Trauma
 - a. Trauma results in profound metabolic alterations, beginning at the time of injury and persisting until wound healing and recovery are complete

- b. Hypermetabolism, marked protein catabolism with increased nitrogen loss and muscle wasting occurs
- c. Hyperglycemia, glucosuria, and impaired glucose tolerance occur
- 3. Burns
 - a. Marked hypermetabolism and increased nitrogen loss: nitrogen loss parallels energy expenditure; as a result, energy requirements are determined by the severity of the injury
 - b. Gastrointestinal tract is a major target organ of altered pathophysiology response after burn injury; patients with burns covering more than 30% of their body surface area frequently experience ileus immediately after injury

K. Eating Disorders

- 1. Metabolic and endocrine abnormalities occur related to the degree of starvation. Marked muscle and fat wasting present a classic form of malnutrition similar to marasmus
- 2. On average, normal visceral protein status is present; vitamin deficiencies are rarely reported



VI. Nutritional Assessment

A. Definition

- 1. Nutritional assessment incorporates a review of systems combined with physical, anthropometric, and biochemical measurements that provide the data necessary to make a statement of nutritional health
- 2. Repeat assessments may be used as a monitoring tool to follow the patient's progress during nutritional support or starvation

B. Medical History

- 1. To identify the presence of disease states that affect the nutritional status
- 2. Previous surgeries
- 3. Recent acute illness

C. Fluid and Electrolyte Status

- 1. Increased losses as a result of diarrhea, vomiting, draining wounds, fistulas, abscesses, and effusions

D. Vital Signs

E. Medications

- 1. All prescribed medications
- 2. Over-the-counter medications such as antacids and laxatives may affect absorption of nutrients and lead to depletion of vitamins and minerals
- 3. Herbal preparations/medications

F. Psychosocial Assessment/Social History

1. Social factors that may affect nutrient intake are income, education, ethnic background, religion, environment during mealtimes, and the individual who purchases and prepares meals
2. Psychological and stress-related factors that may affect nutrient intake are weakness, lethargy, malaise, depression, altered body image, and decreased libido

G. Dietary History

1. Past dietary intake and appetite
 - a. Number of meals usually eaten
 - b. Types of food consumed
2. Recent changes in dietary patterns
3. Foods allergies and intolerances
4. Factors affecting dietary intake
 - a. Dietary modifications secondary to chronic disease (e.g. sodium restriction for cardiac disease, and protein and electrolyte restrictions for liver or renal disease)
 - b. Poor dentition or ill-fitting dentures
 - c. Chewing or swallowing difficulties
 - d. Alteration in smell/taste
 - e. Frequent NPO orders for tests, radiographs, and bowel preparation
 - f. Inability to feed self
 - g. Food preference or idiosyncrasies

H. Physical Assessment

1. General physical examination provides several indicators of a patient's nutritional status
 - a. Changes in body systems may represent nutritional deficiencies
 - b. Signs of nutritional deficiencies are observed most commonly in the skin, hair, eyes, and mouth; less commonly affected are the glands and nervous system
2. General appearance and condition
 - a. Normal weight for height, age, and gender
 - b. Good muscle tone and posture
3. Hair changes associated with malnutrition include dull, sparse, thinning hair; changes in pigmentation; easy to pull out; alopecia
4. Skin
 - a. Consider the general characteristics of skin; dryness and flakiness may be associated with vitamin A and essential fatty acid deficiencies
 - b. Follicular hyperkeratosis is associated with vitamin A and essential fatty acid deficiencies; looks like gooseflesh
 - c. Petechiae are associated with vitamin C and K deficiencies; may occur with liver disease or anticoagulation
 - d. Pellagrous dermatosis (hyperpigmentation on body parts exposed to the sun) is associated with niacin deficiency
5. Nails: iron deficiency causes thin, concave, spoon-shaped nails
6. Mouth
 - a. Changes in tongue color and appearance can indicate vitamin deficiencies; for example, magenta color indicating vitamin B₂ deficiency and beefy red color with glossitis significant for vitamin B₁₂ deficiency

- b. May be painful and hypersensitive with fissures; most changes are associated with deficiencies of one or more B vitamins
- c. Taste buds may be atrophied; may appear smooth, pale
- d. Teeth enamel may be mottled, with white or brownish patches, associated with fluorine excess
- e. Spongy, bleeding gums indicate vitamin C deficiency

I. Anthropometric Measurements

1. Definition: anthropometrics is the physical measurement of subcutaneous fat and of muscle mass (somatic protein) stores; muscle mass represents the largest concentration of body protein stores
2. Reliability: anthropometrics can be an unreliable indicator of an individual's nutritional gains
 - a. Peripheral edema can inflate measurements
 - b. Repeated measurements can be highly variable as a result of differences in technique used by those collecting data
 - c. Benefits from nutritional repletion primarily affect cellular function and cannot be readily detected through increases in somatic mass
3. Height: should be accurately measured
4. Evaluation of weight
 - a. Evaluate weight loss history
 - 1) Usual weight should be determined for comparison with current weight
 - 2) Serial weight determinations over a long period provide the most reliable and clinically relevant information for nutritional assessment
 - b. Current weight can be compared with ideal values
 - 1) Ideal body weight may not be a clinically reliable determination of weight loss and malnutrition
 - c. Current weight as a percentage of usual weight may be a more accurate indication if a reliable usual weight cannot be determined
 - 1) Mild malnutrition: 85% to 95%
 - 2) Moderate malnutrition: 75% to 84%
 - 3) Severe malnutrition: <75%
 - d. Consider recent percentage of weight change: losses greater than 10% in any period of time may be clinically significant

J. Laboratory Data Measurements

1. Proteins present in the serum are indications of the body's visceral proteins. All visceral protein measurements should be interpreted in the context of the patient's clinical condition because they are also affected by changing fluid balance, sepsis, medications, and any stressful insult
2. Serum albumin
 - a. Measures visceral protein; maintains plasma oncotic pressure and functions as a carrier protein
 - 1) Represents 50% to 65% of the total protein
 - 2) Approximately 40% of the protein mass is in circulation
 - b. Popular indicator of chronic malnutrition because protein synthesis is depressed, and existing protein is consumed to maintain bodily functions when nitrogen intake is inadequate

- c. Although albumin levels may have prognostic or diagnostic values, they have been found to be poor indicators of short-term nutritional support effectiveness
 - 1) Low levels may reflect decreased liver function, rather than nutritional deficiency because it is a liver-synthesized protein
 - 2) Plasma levels may also be decreased from fluid changes secondary to increased vascular permeability, increased catabolism, or losses from gastrointestinal tract or burn wounds
 - d. Half-life is 18 days; therefore, changes in synthesis are reflected slowly, and acute changes in nutrition will not be reflected
 - 1) Normal levels: >3.5 g/dL
 - 2) Mild depletion: 2.8 to 3.4 g/dL
 - 3) Moderate depletion: 2.1 to 2.7 g/dL
 - 4) Severe depletion: <2.1 g/dL
3. Serum transferrin
- a. Measures visceral protein; carrier protein for iron and plays an important role in iron metabolism
 - 1) Assayed directly or can be estimated from the total iron-binding capacity
 - 2) Levels measured directly are consistently lower than those measured indirectly
 - b. Half-life is 8 days, so it is a more sensitive indicator of acute nutritional changes
 - 1) Normal (measured directly): >200 mg/dL
 - 2) Mild depletion: 150 to 200 mg/dL
 - 3) Moderate depletion: 100 to 150 mg/dL
 - 4) Severe depletion: <100 mg/dL
 - 5) Note: normal levels can range from 160 to 356 mg/dL, with a mean of 258; this wide range of normal values is the main drawback in using this test
4. Prealbumin
- a. Measures visceral protein; carrier protein for retinol-binding protein
 - b. Half-life is 24 to 48 hours, so it is sensitive to acute changes in protein status
 - c. Very sensitive to sudden demands on protein synthesis
 - 1) Normal level: 20 mg/dL
 - 2) Mild depletion: 10 to 20 mg/dL
 - 3) Moderate depletion: 5 to 9 mg/dL
 - 4) Severe depletion: <5 mg/dL
5. Retinol-binding protein
- a. Measures visceral protein status; carrier protein for retinol in plasma
 - b. Half-life is 10 to 18 hours, reflecting acute changes in protein status and thus extremely sensitive to sudden changes in protein synthesis with limited clinical usefulness due to short half-life
 - c. Normal values: 3 to 5 mEq/dL

K. Immunocompetence Testing

- 1. Was used in the past; however, it is no longer a standard in clinical assessment

L. Serum Glucose

- 1. Hyperglycemia: signs and symptoms include glucose excretion in urine, polyuria, dehydration and thirst, fatigue, visual disturbances, and weight loss

2. Hypoglycemia: signs and symptoms include tachycardia, anxiety, trembling, hunger, sweating, and piloerection

M. Nitrogen Balance

1. The difference between the amount of nitrogen intake and output. The clinical measurement of nitrogen balance allows for the determination of the daily net of protein balance; it is useful for the assessment of baseline nutritional status and as a method for monitoring the progress of nutritional support
 - a. Anabolism: positive nitrogen balance
 - b. Catabolism: negative nitrogen balance
2. Measurement of nitrogen balance
 - a. Nitrogen intake is compared with the amount of nitrogen excreted.
Calculate a nitrogen balance as follows:
 - 1) Total protein intake divided by 6.25 to obtain grams of nitrogen
 - 2) Subtract urinary nitrogen in total grams as measured on a 24-hour urine collection
 - 3) Add factor for insensible losses and fecal losses (2 to 4g) to the total urinary grams of nitrogen
 - b. Urinary losses are obtained from a 24-hour urine collection
 - 1) Ninety percent of the nitrogenous breakdown products of protein metabolism are easily measured in the urine as urea nitrogen
 - 2) Other nitrogen losses are estimated as follows: insensible, 5 mg/kg; gastrointestinal, 12 mg/kg

N. Hemoglobin/Hematocrit

1. Anemia usually accompanies protein deficiency

O. Other Laboratory Values to Monitor

1. Serum electrolytes
2. Serum vitamin levels
3. Serum trace element levels
4. Serum liver enzymes
5. Coagulation studies
6. Serum lipids
7. Urinary protein, glucose, and acetone



VII. Parenteral Solution Composition

A. Components of PN Solutions

1. Three essential macronutrients are typically included in PN regimens: protein, carbohydrates, and fats
 - a. Carbohydrates and fats act as energy substrates
 - b. Protein provides amino acids and nitrogen required for tissue synthesis and repair
2. Other PN components include electrolytes, vitamin, mineral and trace element solutions, water and sometimes medications, such as insulin or H₂ receptor antagonists (e.g., famotidine, ranitidine)

B. Protein Solutions

1. Composition: protein is added to PN formulations as crystalline amino acids
2. Concentrations/caloric value
 - a. Amino acids provide 4.0 calories/g but are not always included in the calculated intake; all amino acids should be used to create endogenous proteins, not oxidized to produce energy
 - b. Amino acid solutions in PN solutions are approximately 16% nitrogen, so 6.25 g of protein provide 1 g of nitrogen. Final PN amino acid concentrations of >60 g/L are difficult to formulate if they are to contain adequate calories; 3 L/day places an upper limit on amino acids of approximately 180 g/day
3. Formulations
 - a. Protein solutions are available in concentrations from 3% to 20% and come with or without electrolytes; these products are produced by several companies that manufacture similar amino acid mixtures which usually contain both essential and nonessential amino acids
 - b. Special amino acid formulations containing higher amounts of BCAAs are available and may be indicated for certain disease states, such as hepatic encephalopathy, renal failure, metabolic stress, trauma or thermal injury. Improved outcomes have not been demonstrated in clinical trials with these more expensive products and their use should be carefully scrutinized

C. Carbohydrate Solutions

1. Dextrose (glucose)
 - a. Is the most commonly used carbohydrate source in PN solutions
 - b. Available commercially in concentrations varying from 5% to 70%
 - c. Can be given in high concentrations and in large amounts that are well tolerated by most patients after a period of adaptation
 - d. Infusion of dextrose concentrations >10% requires central venous access
 - e. Individual formulas are chosen according to the patient's estimated energy requirements and respiratory, cardiac, renal, and volume status
 - f. Caloric value
 - 1) Provides 3.4 calories/g (it is possible to meet daily caloric needs with carbohydrate solutions alone)
 - 2) May be used as the exclusive nonprotein caloric source or may be administered in varying proportions with lipids: when used with lipids, at least 100 to 150 g of glucose should be supplied to achieve the maximum impact on nitrogen balance and to use it for certain key tissues, notably the central nervous system, peripheral nerves, red blood cells, white blood cells, active fibroblasts, and certain phagocytes that normally require glucose as the sole or major energy source
- g. Considerations
 - 1) Administration rates are dependent on the solution's concentration as well as the patient's needs
 - 2) With glucose infusions of more than 4 to 5 mg/kg/minute, progressive hyperglycemia may occur because tissues that traditionally use the glucose become insulin-resistant and do not extract it from the bloodstream

- 3) Excessive glucose intake should be avoided because it may precipitate an increase in the synthesis and storage of fat, hepatic dysfunction, and excessive production of carbon dioxide, causing respiratory failure in some patients
 - 4) The pancreas secretes extra insulin to metabolize infused glucose; if a hypertonic solution is discontinued suddenly, a temporary excess of insulin in the body may cause nervousness, sweating, and weakness
2. Glycerol
 - a. Less frequently used carbohydrate substrate that provides 4.3 kcal/g
 - b. Commercially available in a premixed peripheral PN solution that contains 3% amino acids and 3% glycerin
 - c. Provides a protein-sparing effect similar to that of an intravenous fat emulsion
 - d. The use of glycerol as an exclusive energy source is relatively recent and requires further clinical investigation
 3. Fructose: used in 5% and 10% solutions combined with glucose and xylitol, used in Europe; its use is not popular in the United States

D. Fat Emulsions

1. Used as a caloric source and to correct or prevent EFAD
2. Composition
 - a. Fats are provided by the administration of commercially available lipid emulsions that are aqueous dispersions composed of a neutral triglyceride such as soybean or safflower oil
 - 1) Egg yolk phospholipid is added as an emulsifying agent
 - 2) Glycerol is added to achieve isotonicity with plasma
 - b. Fat emulsions contain only long-chain fatty acids and are a rich source of essential fatty acid, linoleic acid
 - c. Medium-chain triglycerides are only used clinically in enteral nutrition; their intravenous use is being investigated
 - d. Safflower oil emulsions contain 77% linoleic acid and 4% linolenic acid
 - e. Soybean oil emulsions contain 49% to 60% linoleic acid and 6% to 9% linolenic acid
3. Available preparations
 - a. Products available in the United States contain either all soybean oil, or a combination of soybean and safflower oils; both soybean and safflower oil emulsions are effective as energy sources and in preventing or reversing EFAD. These products consist entirely of omega-6 fatty acids
 - b. Fat emulsions are available in 10% and 20% concentrations for PN preparation or direct infusion. A 30% solution is also available but restricted to use in the preparation of PN solutions
 - c. Fat emulsions consisting of omega-3 fatty acids (i.e. fish oils) may have beneficial effects in some disease states. However, they are not currently available in the United States, unless used as part of a compassionate use protocol
4. Osmolarity: lipid emulsions range in osmolarity from 280 to 340 mOsm/L, depending on the concentration of the emulsion; because of their isotonic nature, they can be administered peripherally as well as centrally
5. Caloric value
 - a. 10%: 1.1 calories/mL
 - b. 20%: 2.0 calories/mL

6. Dosage
 - a. At least 2% to 4% of calories from linoleic acid should be provided to prevent EFAD; 500 mL of 10% fat emulsion twice a week should provide adequate amounts of essential fatty acid
 - b. Infusion of IV lipids has been associated with impaired immune response; rapid infusion may result in impaired reticuloendothelial function; fat is usually restricted to 30% of calories or 1 g/kg/day
 - c. Higher percentages of fat in the PN formulation may be indicated in patients with hyperglycemia, carbon dioxide retention, and hypermetabolism
7. Adverse reactions include anaphylaxis, back pain, chest pain, cyanosis, dizziness, dyspnea, elevated temperature, headache, nausea, and vomiting
8. Monitor patient tolerance
 - a. Review liver function tests, blood coagulation studies, and cholesterol panel, including triglycerides
 - b. Be alert for complications, such as transient increases in liver enzymes, blood dyscrasia, and hyperlipidemia
9. Contraindications
 - a. Significant hypertriglyceridemia
 - b. Allergy to eggs can lead to rare allergic reactions as egg phospholipids are used as an emulsifier

E. Electrolyte Preparations

1. Commercially available as single salts or mixtures for PN compounding
2. Multiple-component electrolyte injections contain sodium, potassium, calcium, magnesium, chloride, and acetate salts
3. It is important to consider that most amino acid formulations are available with and without electrolytes. Electrolytes included in AA products should be included in the patient's daily intake total
4. Individual electrolyte needs are highly variable in patients receiving PN
 - a. Patient-specific electrolyte requirements are dependent on acid-base balance, renal and cardiac function, disease-specific needs, and abnormal losses requiring replacement
 - b. Based on normal organ function and normal losses, the standard daily ranges for electrolytes in PN are as follows:
 - 1) Sodium: 1 to 2 mEq/kg
 - 2) Potassium: 1 to 2 mEq/kg
 - 3) Phosphorus: 20 to 40 mmol
 - 4) Magnesium: 8 to 20 mEq
 - 5) Calcium: 10 to 15 mEq
 - 6) Chloride: as needed to maintain acid-base balance
 - 7) Acetate: as needed to maintain acid-base balance
5. Generally, acid-base balance can be maintained by providing approximately equal amounts of chloride and acetate in the PN product
 - a. Acetate or lactate salts may be substituted for chloride salts if the patient receives excessive amounts of chloride and experiences hyperchloremic acidosis
 - b. Larger amounts of acetate or lactate salts have been used in acidotic patients in an attempt to improve bicarbonate levels and help correct acidosis

F. Multiple Vitamin Injection (MVI)

1. All patients receiving PN should receive daily parenteral multiple vitamins
2. The daily intravenous vitamin requirements established by the American Medical Association are as follows:

Table 8–1 Vitamin recommended daily amount

Vitamin Recommended Daily Amount	
Thiamin (B ₁)	6 mg
Riboflavin (B ₂)	3.6 mg
Pyridoxine (B ₆)	6 mg
Cyanocobalamin (B ₁₂)	5 mcg
Niacin (B ₃)	40 mg
Folic acid (B ₉)	600 mcg
Pantothenic acid (B ₅)	15 mg
Biotin (B ₇)	60 mcg
Ascorbic acid (Vitamin C)	200 mg
Vitamin A	3,300 International units
Vitamin D	5 mg
Vitamin E	10 International units
Vitamin K	150 mcg

3. Vitamin K has recently become available in intravenous multiple vitamin formulations and is commonly included in a patient's daily regimen. Prior to its inclusion in MVI products, vitamin K was provided separately, either by adding 5 mg to the PN solution or administering 5 mg intramuscularly once a week. This practice is no longer common

G. Trace Elements

1. Are considered essential for numerous physiological processes
2. Are usually provided in PN formulations daily as a fixed-dose combination product, which meets the needs of most patients
3. Patients with severe hepatic or renal disease, or patients on long-term PN (e.g. home infusion patients) may require adjustments and individualization of trace elements dosages
4. Common trace element supplementation to adult PN formulations:

Table 8–2 Trace element supplementation to adult PN formulations

Trace element	Standard intake
Chromium	10 to 15 mcg
Copper	0.3 to 0.5 mg
Manganese	60 to 100 mcg
Selenium	20 to 60 mcg
Zinc	2.5 to 5 mg
Iron	Not routinely added

H. Insulin

1. Hyperglycemia is the most common complication of PN, and insulin is often added to PN to aid in blood glucose control
 - a. Only regular insulin is appropriate for the administration in a PN solution
 - b. As a starting point, the addition of 1 unit of regular insulin per 10 g of dextrose in the PN solution is commonly seen
 - c. A continuous regular insulin infusion offers a more flexible option for managing patients with challenging blood glucose control. It can easily be adjusted or stopped based on the patient's blood glucose
2. Insulin is considered chemically stable in PN solutions; a certain degree of absorptive loss of insulin to the solution container, administration set, and filter has been demonstrated
 - a. It has been demonstrated that the availability of insulin can range from 50% to 95% with the use of regular human insulin
 - b. Absorptive losses of insulin can be overcome by increasing the dose with subsequent solution admixtures until the desired effect is reached

I. Heparin

1. Heparin in low doses (0.5 to 1.0 unit/mL of final PN volume) is sometimes added to PN solutions to help maintain catheter patency and reduce the risk of thrombophlebitis, especially with peripheral PN. The risks and benefits of heparin in PN make it a variable practice from institution to institution
2. Heparin should not be added to PN solutions in patients with active bleeding, thrombocytopenia, heparin-induced thrombocytopenia (HIT) or heparin allergy
3. Another pharmacologic effect of heparin is improving the clearance of intravenous fat emulsion from the bloodstream through activation of the lipoprotein lipase enzyme

J. Histamine Receptor (H_2) Antagonists

1. Rationale for use: H_2 antagonists (e.g., famotidine and ranitidine) inhibit gastric acid secretion and are used to provide stress ulcer prophylaxis
2. Dosing considerations
 - a. Daily adult dose can be added to daily PN formulation (e.g., famotidine 40 mg/day)
 - b. Dose reductions are required in patients with renal insufficiency
 - c. Patients receiving an oral or intravenous proton pump inhibitor (e.g., omeprazole, lansoprazole) usually do not also need an H_2 antagonist

K. Total Nutrient Admixture

1. Total Nutrient Admixture (TNA) solutions are single container PN formulations that contain the lipids (intravenous fat emulsions) as well as the other PN components: carbohydrates, amino acids, vitamins, minerals, trace elements, water, and other additives
2. TNA solutions are typically infused over a 24-hour period and are also known as "3-in-1" PN solutions
3. When the lipids are infused separately from the rest of the PN formulation, the product is known as a "2-in-1" PN

4. Advantages of 3-in-1 PN solutions
 - a. All components are compounded aseptically in the pharmacy
 - b. Less manipulation of the closed system during administration, which decreases the risk of contamination
 - c. Less nursing time to hang one bag per day with no additional piggyback connections needed (e.g., lipids in a 2-in-1 system)
 - d. Glucose and venous access tolerance may be better in some situations
 - e. Modified solutions have been successfully used peripherally
5. Disadvantages of 3-in-1 PN solutions
 - a. Three-in-one solutions cannot be filtered through a 0.2-micron bacterial-retentive filter; therefore, a concern for microbial growth exists
 - 1) In vitro research has shown that *Candida albicans* can grow in all PN solutions; however, bacterial species seem to require a PN solution containing lipids
 - 2) A 1.2-micron filter may be used and will remove *Candida*; however, it will not remove *Staphylococcus* or *Escherichia coli*
 - b. PN formulations that contain lipid emulsions are less stable, more prone to separation and more sensitive to destabilization with certain electrolyte concentrations (e.g., calcium and phosphorus)
 - c. Certain medications are not compatible with lipid emulsions
 - d. Catheter occlusion is more common with daily lipid administration
 - e. Difficult to visualize precipitate or particulate matter in the opaque admixture
 - f. Less attractive in pediatric settings due to pH and compatibility considerations

L. PN Formulas

1. Use a standard formula ordering sheet to specify the protein, calorie, and electrolyte content of each solution
2. Peripheral PN
 - a. Standard solutions contain: 100 to 150 g dextrose with 1 to 1.5 g amino acids/kg (final concentrations of 5% to 10% dextrose and 1.75% to 3.5% amino acids) along with 500 mL of 10% or 20% lipids and electrolytes, trace elements, and vitamins
 - b. This provides
 - 1) 25 to 53 calories/100 mL
 - 2) 17 to 37 nonprotein calories
 - 3) 2 to 4 g of protein
 - c. Infusions should be limited to solutions that are lower than 600 mOsm/L
 - 1) Reports have shown that with the use of 3-in-1 solutions, a higher osmolarity may be tolerated
 - 2) No greater than 10% final concentration of dextrose should be infused peripherally
3. Central PN
 - a. Standard solutions contain final concentration
 - 1) 4.25% amino acids
 - 2) 25% dextrose
 - 3) Electrolytes, trace elements, and vitamins
 - b. This provides
 - 1) 105 calories/100 mL
 - 2) 85 nonprotein calories

- 3) 5 g protein
- 4) 106:1 nonprotein-calories-to-nitrogen ratio
- c. Addition of 500 mL of 10% lipid emulsion twice weekly provides an average of 157 additional calories per day
4. Standardized ("premixed") PN solutions
 - a. Premixed, commercially prepared PN solutions contain concentrated amino acids plus concentrated dextrose solutions in multichamber bags. These chambers are mixed together prior to infusing into the patient. The solutions may or may not contain standard electrolytes
 - b. Advantages of premixed PN solutions
 - 1) Improve prescribing to include a complete, balanced formulation
 - 2) Reduce potential stability and compatibility issues as formulations are developed taking these into consideration
 - 3) Less preparation time/workload
 - 4) Can be used in home care settings and at institutions that do not have facilities to compound PN products in a USP <797> compliant environment
 - 5) Potential cost savings with decreased waste
 - 6) Ability to initiate PN therapy more quickly, or make changes in a current formulations more rapidly
 - c. Disadvantages of premixed PN solutions
 - 1) Inability to individualize PN formulation for complicated patient comorbidities (e.g., renal or hepatic disease, glucose intolerance, neonatal/pediatric patients, critical illness, home care patients with large-volume fluid and electrolyte losses)
 - 2) Do not contain IV lipids; must be provided separately
 - 3) Require chambers to be engaged prior to use. Potential for this step to be forgotten, resulting in patient receiving only dextrose or amino acid compartment
 - 4) Additives still usually need to be added to premixed bags (e.g., electrolytes, insulin), so manual preparation not eliminated
 - 5) Volumes may not be sufficient for 24-hour infusion, which is standard in many settings
 - d. Premixed PN solutions may provide benefits in some institutions and settings. Careful evaluation of current practices, operations, and patient safety are required to determine the role of these products in each setting
5. Nonstandard solutions
 - a. Institutions utilizing 3-in-1 PN solutions typically provide them individualized to meet the needs of each patient
 - b. The 24-hour hang time with 3-in-1 formulations allows changes to be made daily to address electrolyte, insulin, or macronutrient adjustments
6. Formulations for infants and young children
 - a. Amino acids such as histidine, tyrosine, cysteine, and taurine, which are nonessential in adults, may be essential for infants and young children
 - b. Special amino acid formulations are available to meet these needs

M. Disease-Specific Formulations

1. Specialty amino acid products are commercially available and marketed for use in specific disease states, such as renal failure, hepatic failure, and metabolic stress

2. These modified formulas usually consist of primarily essential amino acids (e.g., renal formulations) or increased amounts of BCAAs (e.g., hepatic and stress formulations). These products are more expensive than standard amino acid formulations
3. Disease-specific products have theoretical advantages, but the evidence from clinical trials has not shown consistent improvement in patient outcomes. Current primary literature should be consulted and evaluated as part of the decision-making process on whether to use these products
4. Concentrated amino acid solutions (15% to 20%) provide an option for fluid restricted, renal patients. These provide similar amino acid profiles as found in regular AA solutions, but in a concentrated form, which minimizes PN volume



VIII. Preparations and Storage of Parenteral Admixtures

A. Solution Compounding

1. PN should be compounded in the pharmacy using aseptic technique under a laminar flowhood

B. Storage

1. Nutritional admixtures should be used immediately after preparation or refrigerated at 4°C until used
2. The acceptable length of time for refrigeration is based on the stability of the admixed components
3. When solutions are stored for more than 24 hours, quality control measures must be initiated to ensure the acceptability of the solutions
4. Lipid emulsions are refrigerated or stored at room temperature

C. Hang Time

1. PN solutions must be completely infused or discarded within 24 hours after hanging



IX. Solution Administration Regimens

A. Considerations for Initiation

1. Confirmation of central vascular access device (CVAD) tip location must be done before initiating central PN; before initiating PPN, careful assessment of the peripheral site must be done
2. Solution labels should be carefully checked and compared with licensed independent practitioner's (LIP's) orders before administration
3. Solution should be removed from refrigerator 1 hour before hanging
4. Before administration, check solution container for leaks, cracks, clarity, expiration date; with 3-in-1 solutions, check for pink discoloration or separation of oils

B. Rate of Delivery

1. Rate recommendations
 - a. It was previously believed that PN should be gradually increased to the prescribed rate to avoid hyperglycemia; research using a 3-in-1 admixture allows for the start of PN at full support
 - b. The initial rate for starting PN is based on a clinical judgment of the patient's ability to tolerate the volume and macronutrients. In most cases, the goal rate of PN can be reached in 2 to 3 days
 - c. PPN does not require tapering and may be initiated at the desired rate
2. Consistency and accuracy of infusion rate
 - a. PN must be administered at a constant rate
 - b. Changes in rate should be gradual
 - c. Maintain consistency and accuracy with an electronic infusion device

C. Discontinuation

1. Occurs when patient is likely to resume full oral intake within 48 hours
2. To avoid potential complications such as hypoglycemia, PN should not be abruptly discontinued; some admixtures are more likely than others to cause problems with blood glucose shifts
3. Reduction of PN infusion rates should be in conjunction with increases in caloric intake by the oral or enteral route
 - a. As the PN is decreased, fluid intake must also be increased
 - b. Consumption of half the estimated nutrient requirements should be achieved before PN use is discontinued
4. Rate reduction considerations
 - a. The patient's diagnosis, condition, and length of therapy, to evaluate whether tapering is required for discontinuation
 - b. Tapering may be accomplished over a few hours by progressive reduction in the rate of infusion (consider glucose intake at the time of weaning)
 - c. PPN does not require tapering

D. Cyclic Regimens

1. Description
 - a. Involves the infusion of PN on a cyclic basis over 8 to 16 hours versus the standard continuous infusion over a 24-hour period
2. Benefits
 - a. Improves quality of life through resumption of normal daily activities
 - b. Allows the patient freedom from pumps during daytime hours, increased psychologic well-being
 - c. Allows for increased mobility, which maintains somatic muscle
 - d. Allows for more physiologic hormonal responses and stimulation of appetite
 - e. Prevents or used in the treatment of hepatotoxicities induced by continuous PN; reversal of fatty liver and enzyme elevations and faster albumin level recovery
 - f. Prevents or used in the treatment of EFAD in patients receiving fat-free PN; reduced insulin levels during PN-free periods allow for lipolysis and release of essential linoleic acid

3. Indications
 - a. Patients who have been in stable condition on continuous PN and require long-term support
 - b. Patients who are receiving PN at home
 - c. Patients who can handle a total infusion volume in a shortened time period
 - d. Patients who require PN for only a portion of their nutritional needs
 - e. Patients who have hepatic steatosis or for the prevention of hepatic steatosis
4. Recommendations for initiation/termination
 - a. PN can be transitioned to cyclic administration once tolerance to 24-hour continuous infusion has been obtained; the switch is accomplished by gradual decreases in hours of infusion
 - b. The hourly rate is determined by dividing the total required volume of PN by the number of hours the PN is to be infused; the cyclic PN is usually administered at rates no more than 200 mL/hour
 - c. The ability to tolerate the glucose and fluid volume determines how rapidly the solution can be infused; with the average patient receiving 2 to 3 L, this typically requires a period of 12 to 16 hours to complete; patients receiving 2 L of fluid may tolerate 8-hour infusions
 - d. For patients without complications such as glucose intolerance or a precarious fluid balance, a 12-hour cycling regimen is generally used; when glucose or fluid management is difficult, the infusion time can be lengthened
 - e. PN may need to be initiated gradually unless the goal rate is fairly low; to avoid the complications of abrupt changes in glucose, there must be a period of escalation to the maintenance rate as well as tapering from the maintenance rate; various procedures have been reported, with tapering periods ranging from 1 to 2 hours; usually accomplished by reducing the rate by one-half in 15- to 30-minute increments before discontinuing the infusion; some electronic infusion devices can be programmed to taper
 - f. Usually infused at night and turned off during the daytime hours; the infusion schedule can be designed around the patient's activity schedule
5. Considerations
 - a. Cardiovascular status must accommodate the large fluid volume infused during the cyclic phase
 - b. Requires twice as many central line manipulations for cyclic PN versus continuous PN in each 24-hour period; increased manipulations may increase the risk of infection
6. Monitoring
 - a. Patients receiving cyclic regimens need careful monitoring for the development of rebound hypoglycemia after cessation of the PN solution
 - b. Test for blood glucose 1 hour after tapering the infusion and anytime a patient experiences symptoms associated with hypoglycemia, including nausea, tremors, sweating, anxiety, or lethargy
 - c. Hyperglycemia can develop during the peak flow rate and is indicated by blood glucose greater than 250 mg/dL
 - 1) Always evaluate for an infectious process
 - 2) If hyperglycemia persists, lengthen the infusion time
 - 3) Insulin should be added to control infusion-related hyperglycemia
 - 4) Percentage of calories derived from fat should be maximized in an attempt to control the blood glucose
 - d. Inability to control hyperglycemia may require changing to continuous PN

E. Lipids

1. Administration considerations
 - a. Before administration, inspect for frothiness, separation, or oily appearance
 - b. The emulsion should be allowed to come to room temperature if it has been refrigerated; administration of cold emulsion can cause pain and blanching of the skin
 - c. May be administered in conjunction with PN through an injection port close to the injection site below any filters, or as a separate infusion
 - d. May be administered peripherally because of the isotonic nature
 - e. Lipids should not be filtered because filtering can result in clogging of the filter and perhaps separation of the emulsion: if a 3-in-1 solution is being administered, a 1.2-micron filter shall be used
 - f. When hung as a separate infusion, infusions of IV fat emulsions (lipids) should not hang for longer than 12 hours
2. Rate of delivery
 - a. Follow manufacturers' recommendations for rate and dose
 - b. Test dose is recommended to allow time to note any adverse reactions
- C. In adults:
 - 1) Ten percent fat should be infused at a rate of 1 mL/minute for the first 15 to 30 minutes
 - 2) Twenty percent fat should be infused at a rate of 0.5 mL/minute for the first 15 to 30 minutes
 - 3) Traditionally, 10% solutions are infused over 4 to 6 hours, and 20% solutions are infused over 6 to 8 hours; slower infusions of 12 hours and up to 24 hours (particularly with 3-in-1 solutions) have been used more frequently



X. Medication Compatibility with PN

A. PN Solutions

1. Although PN solutions provide IV access in patients who at times have access challenges, PN solutions should not be considered a first-line option for the administration of IV medications
2. The PN admixture is a highly complex admixture and has a high risk for physiochemical interactions with medications and nutrients
3. In situations where there are no other alternatives, the medication stability and compatibility with the PN formulation must be assured

B. Stability Considerations

1. PN solutions provide a greater buffering capacity than either dextrose or saline solutions; however, the physical and chemical stability of drugs can be at risk when infused with a PN solution
2. The physical stability of the solution must be considered, as must the physicochemical stability of the additives
3. Chemical incompatibility may render the medication ineffective
4. It is not always possible to determine the stability or compatibility of the formulation from available resources because of the complex nature of PN solutions. Factors that affect compatibility of PN and medications include concentrations, pH, temperature, and order of mixing

C. Medications and PN Solutions

1. Check with a pharmacist for drug compatibility before administering any medication simultaneously with a PN solution. Compatibility will vary depending on the composition of each individual PN bag
2. Insulin, famotidine, ranitidine, and heparin are often compatible with PN and added to formulations
3. Medications should never be added to a PN solution that is currently hanging at the patient's bedside



XI. Vascular Access

A. Peripheral Venous Access

1. Peripheral veins are appropriate for the administration of PPN only
 - a. Appropriate vein selection: vein selection should allow for adequate dilution of the hypertonic PPN solution
2. Device selection: the smallest gauge and shortest length catheter should be selected

B. CVAD

1. A CVAD is required for the administration of central PN solutions
2. Insertion sites include the subclavian vein, internal jugular vein, external jugular vein, femoral vein, and basilic or cephalic veins
3. Catheter types/selection considerations
 - a. Percutaneously placed (nontunneled) CVADs
 - 1) Commonly used for short-term administration of PN
 - 2) Use a CVAD with a minimum number of lumens essential for patient care
 - b. Peripherally inserted central catheters (PICCs) are appropriate for PN administration
 - c. Tunneled CVADs are commonly used for long-term PN administration
 - d. Implanted vascular access ports
 - 1) Appropriate for long-term PN administration
 - 2) Consideration must be given to needle change frequency requirements



XII. Administration Equipment

A. Electronic Infusion Devices

1. Required to provide an accurate, consistent rate of delivery
2. Pumps: deliver a specific volume of solution during a specific period of time
 - a. Pressure is exerted to expel the fluid
 - b. Advances in infusion device technology have provided pumps that allow multiple rate programming and automatic cyclic regimens
 - c. Pumps are available in pole mount and ambulatory models

B. Administration Sets

1. Set change frequency
 - a. Should be changed immediately on suspected contamination or when the integrity of the product has been compromised

- b. Should be changed using aseptic technique
- c. Solution container changes, addition of add-on devices, and other set manipulations should coincide with set change
 - 1) Administration sets used for nonlipid-containing PN solutions should be routinely changed no more frequently than every 96 hours
 - 2) Three-in-one: administration sets should be changed every 24 hours
 - 3) Lipids: administration sets used for lipid emulsion should be discarded after each unit, unless additional units are administered consecutively; when lipids are administered consecutively, the administration set should be changed every 24 hours
- 2. All connections shall be of luer-lock design to avoid accidental disconnection

C. Filters

- 1. PPN/PN solutions: should be filtered with a 0.2-micron filter
- 2. Three-in-one solutions: should be filtered with no smaller than 1.2-micron filter
- 3. Lipids: are not routinely filtered



XIII. Complications

A. Technical

- 1. Peripheral catheter-related complications
 - a. Phlebitis/thrombophlebitis: related to hyperosmolarity, acidic pH, and particulate matter
 - 1) Addition of heparin 1,000 units, hydrocortisone 5 mg, or sodium bicarbonate 1.8 mEq to each liter may decrease the incidence of phlebitis/thrombophlebitis
 - 2) Concurrent infusion of lipid emulsion buffers pH and dilutes hypertonic dextrose
 - 3) Filtration may decrease phlebitis
 - b. Infiltration/extravasation: because of the hypertonic nature of PPN solutions, sites must be monitored frequently
 - 1) Depending on the solution composition, severe tissue damage may occur
- 2. CVC-related insertion complications (see Chapter 1)

B. Septic Complications

- 1. Infection associated with PN may be related to microbial contamination of the catheter or the solution
- 2. Parenteral solution-related complications
 - a. Bacterial survival in PN is dependent on the pH and lipid content of PN. Fungi, particularly *C. albicans*, proliferate in standard solutions
 - b. In view of strict pharmacy protocols required in the compounding of PN solutions, contamination is a rare event
 - d. To determine the source of infection, careful examination is needed
 - 1) Solutions for particulate matter or turbidity
 - 2) Connections for possible leaks or cracks in administration set or filters
 - e. Change administration set and solution, and culture any fluid remaining in the delivery system

3. Catheter-related bloodstream infections (CRBSIs) are the leading complications associated with PN use
 - a. Migration of skin organisms at the insertion site is a common route of infection for short-term percutaneously inserted catheters
 - b. Contamination of the catheter hub contributes substantially to intraluminal colonization of long-term tunneled catheters
 - c. Occasionally, catheters become hematogenously seeded from another focus of infection. Rarely, infusate contamination is the cause of CRBSIs
4. Symptoms associated with CRBSI
 - a. Fevers and chills especially with start of infusion
 - b. Monitor blood glucose levels; hyperglycemia in a patient who has been in stable condition generally signals the onset of sepsis
5. The following are critical issues and interventions in reducing the risk of infection:
 - a. Staff education and training regarding catheter care
 - b. Maximal sterile barrier precautions during catheter/device insertion
 - c. Using a >0.5% chlorhexidine/alcohol for skin antisepsis
 - d. Avoiding routine CVAD replacements as a prevention measure
 - e. Using antiseptic/antibiotic impregnated CVADs for short-term therapy
 - f. Using chlorhexidine-impregnated dressings if infection rates are high

C. Metabolic Complications

1. Refeeding syndrome
 - a. Usually represents the initial stage of aggressive and excessive nutritional repletion
 - b. Severely malnourished individuals may have diminished cardiac reserves
 - c. Primary cause is the shift from stored body fat to carbohydrate metabolism
 - d. Initiation of nutrition must begin cautiously; an overly aggressive approach can result in cardiac and pulmonary failure
 - e. The process is reversed when the body has re-established normal electrolyte and albumin balance
 - f. Patient may experience
 - 1) Dyspnea
 - 2) Hypercapnia
 - 3) Tachycardia
 - 4) Elevated venous pressure
 - 5) Congestive heart failure
 - 6) Cardiac arrest
 - g. Carefully monitor volume and electrolyte intake and balance; carefully adjust caloric input and source, depending on an appropriate mixture of carbohydrate and fat calories
2. Electrolyte imbalances: most common imbalances are related to potassium, phosphorus, and magnesium
 - a. During active protein synthesis and anabolism, the level of the aforementioned ions in the plasma may fall
 - 1) Careful monitoring of laboratory values and general patient condition to detect deficiencies and excesses is required
 - 2) Correct imbalances through a change in the prescription

- b. Phosphorus
 - 1) Hypophosphatemia is commonly found during the initial phases of nutritional support
 - 2) As PN is administered, there is a redistribution of phosphate into muscle, protein synthesis begins, and phosphate is driven into the intracellular space as a component of adenosine triphosphate
- c. Potassium is driven into the intracellular space during PN administration
 - 1) Potassium binds to cells in many metabolic processes, and serum potassium can become markedly depleted in aggressive refeeding
 - 2) Insulin administration further intensifies intracellular potassium and phosphate shifting
- d. Magnesium is driven into the intracellular space during PN administration
- e. Sodium is driven from the intracellular space into the extracellular space to maintain homeostasis
- 3. Trace element deficiencies: patients receiving PN are at risk of depletion; avoid by daily supplementation of trace elements
- 4. Hyperglycemia/hyperosmolar syndrome
 - a. Common occurrence as a result of the high dextrose concentration in the PN solution; occurs when the rate of infusion exceeds the rate at which the body can metabolize glucose
 - b. Patients with normal insulin response can be expected to tolerate a glucose infusion of 0.5 g/kg/hour
 - c. Rates as great as 1.2 g/kg/hour have been administered without complication
 - d. Serum glucose should be maintained below 150 mg/dL
 - e. Do not increase the rate of infusion to "catch up" if it is behind the schedule
 - f. Factors predisposing to glucose intolerance
 - 1) Presence of overt or latent diabetes mellitus
 - 2) Increased age
 - 3) Pancreatitis
 - 4) Hypokalemia
 - 5) Hypophosphatemia
 - 6) Thiamine or vitamin B deficiency
 - 7) Chromium deficiency
 - 8) Some antibiotics
 - 9) Steroids
 - 10) Conditions of stress, such as sepsis or surgery, result in decreased glucose tolerance and hyperglycemia in as many as 25% of patients receiving PN
- g. Patients started on PN should have routine blood glucose monitoring.
 - 1) Treat with the addition of insulin
 - 2) Can also be minimized by decreasing the rate of infusion or by supplementing the carbohydrate calories with fat
- h. Insulin use in PN should be done in a consistent manner with a defined protocol
 - 1) No single protocol has been found to be superior
 - 2) A common regime is 0.1 units of insulin per gram of glucose in the PN infusion
 - 3) If the patient is significantly hyperglycemic (>300 mg/dL), glucose control should be established before starting PN

5. Hypoglycemia
 - a. Predisposing factors
 - 1) May occur if hypertonic glucose infusions flowing at a rapid rate are abruptly terminated or decreased
 - 2) Can be seen after sudden withdrawal of a prolonged highly concentrated glucose solution infusion, especially when a separate infusion of insulin is being used
 - 3) Uncommon in adults but seen frequently in children
 - 4) Mechanical causes that may lead to hypoglycemia
 - a) Clogged filters
 - b) Kinked tubing
 - c) Piggybacking additional medications
 - b. Symptoms
 - 1) Weakness
 - 2) Trembling
 - 3) Diaphoresis
 - 4) Confusion
 - 5) Chills
 - 6) Rapid pulse
 - 7) Decreased consciousness
 - c. Prevention: ensure a constant flow
6. Vitamin deficiencies: vitamins should be added daily to the solution because most vitamin stores are depleted in malnourished patients
7. Hyperlipoproteinemia: the overproduction of lipids causing hyperlipidemia may result from the infusion of carbohydrates in excess of needs, high infusion rates of lipid emulsions, or reduced use of fat
8. EFAD
 - a. Signs/symptoms
 - 1) Dry scaly skin
 - 2) Hair loss
 - 3) Impaired wound healing
 - 4) Hemolytic anemia
 - 5) Thrombocytopenia
 - b. Prevent or correct the deficiency with administration of a lipid emulsion
9. Pancreatitis: lipid emulsions may produce symptoms of pancreatitis in patients with inflammatory bowel disease (rare); association with PN is usually the result of hypercalcemia or hyperlipidemia
10. Liver function abnormalities: hepatic complications are metabolic abnormalities that have been associated with PN in neonatal, pediatric, and adult patients when used for a long time
 - a. Biochemical and morphologic findings are related to the duration and composition of the nutritional support and the age of the patient
 - b. Adults usually have relatively benign biochemical and morphologic changes, whereas hepatic abnormalities in infants and neonates can be progressive and even fatal
 - c. Cholestasis and gallbladder disease are potential complications of long-term PN
 - d. Causes
 - 1) Etiology is not clear; however, the following factors have been suggested: continuous or excessive dextrose infusion, EFAD, excessive lipid infusion, amino acid imbalance, toxic effects of PN degradation products, and overgrowth of intestinal flora

- 2) Hepatic damage has been reported in one-third of infants receiving PN and as many as one-half of low-birth-weight infants
 - 3) Earliest abnormal finding is an elevated direct or conjugated bilirubin, followed by elevation of other hepatic enzymes
 - 4) Prevalence increases with duration of PN; prolonged PN therapy can lead to irreversible damage
 - 5) Slight rise in the level of alkaline phosphatase commonly occurs but returns to normal and has no clinical significance
11. Respiratory deterioration
 - a. Can occur in patients with pulmonary compromise who are oversupplemented with carbohydrate calories
 - b. Dextrose oxidation produces 21% more carbohydrate than fat; manifested as increased carbon dioxide level, respiratory rate, and decreased tidal volume
 12. Fluid balance
 - a. Dehydration: a consequence of failure to meet fluid requirements
 - b. Excess fluid: results in edema or shortness of breath; make solution more concentrated or extend the cyclic period
 - c. Monitor
 - 1) Pulse
 - 2) Blood pressures including orthostatic changes
 - 3) Condition of mucous membranes
 - 4) Skin turgor
 - 5) Laboratory tests such as blood urea nitrogen, creatinine, hematocrit, and albumin



XIV. Patient Monitoring

A. Parameters to Monitor

1. Daily weight
2. Intake and output
3. Vital signs
4. Laboratory tests—dependent on patient's condition and response
 - a. Hemoglobin
 - b. White cell count
 - c. Electrolytes
 - d. Serum glucose
 - e. Blood urea nitrogen
 - f. Serum creatinine
 - g. Other tests may be required more frequently, depending on the patient's condition
5. Periodic tests to monitor nutritional status and abnormalities
 - a. Serum albumin
 - b. Serum iron
 - c. Visceral proteins such as prealbumin
 - d. Serum calcium
 - e. Magnesium
 - f. Phosphorus
 - g. Triglycerides
 - h. Cholesterol

- i. Transaminase levels, alkaline phosphatase, and bilirubin are important for recognizing the development of liver abnormalities and should be done once a week
6. Glucose tolerance monitoring
 - a. Bedside blood glucose testing—in patients that are not euglycemic, every 6-hour testing is recommended
 - b. Infusion rates may need to be adjusted, along with the addition of insulin
7. Bowel function
8. Appetite, if taking orally
9. Psychological needs



XV. Documentation

A. Clinical Monitoring

1. Assessments
2. Weight changes/presence of edema
3. Results of pertinent laboratory tests

B. Observations Regarding Improved Nutritional Status

1. Improved wound healing
2. Skin integrity
3. Stamina

C. Routine Catheter Care

D. Solution Administration

E. Changes in Oral Intake

F. Psychological and Emotional Support Provided

G. Patient and Family Teaching Relative to Nutritional Therapy

H. Evidence of Discharge Planning



XVI. Home PN

A. Rationale for use

1. Patients requiring extended or permanent intravenous feeding to maintain normal nutrition

B. Discharge Planning

1. Patient and/or caregiver must be willing to participate in the program and basic procedures in the home setting; mastery of procedures is facilitated by the patient's and/or caregiver's literacy

2. Motivation of patient and caregivers
3. Support of family/significant others
4. Physical limitations of patient and/or caregiver; need adequate eyesight and manual dexterity to
 - a. Manage infusion pumps
 - b. Add additives to infusion containers
 - c. Accomplish administration set changes
 - d. Care for the vascular access device
5. Financial and insurance considerations must be carefully evaluated and understood
 - a. Insurance coverage for home therapy should be determined before initiation of patient education
 - b. Insurance carriers vary in the coverage offered for home infusion services
 - c. Coverage must be evaluated and financial planning is implemented as needed
6. Vascular access requirements
 - a. Percutaneously placed nontunneled catheters may be appropriate for short-term periods (2 to 3 months)
 - b. Long-term CVADs such as tunneled catheters or implanted vascular access ports are necessary for long-term vascular access; with implanted access ports, factors associated with the frequency of needle changes must be considered
 - c. PICCs are used in home infusion generally for short-term PN (weeks to a few months)
 - d. The system should be comfortable and must not limit joint mobility or interfere with normal activity or the ability to exercise
 - e. Should allow infusion and maintenance procedures to be performed safely and comfortably
 - f. Should minimize the risk of infection
7. Patient assessment and consultation with appropriate healthcare and support individuals; communication of all patient information and homecare requirements
8. Coordination of services with home health and home infusion agencies
9. Provision of necessary supplies and storage
10. Assess the appropriateness of home environment

C. Emotional and Psychosocial Issues

1. The influence of PN on the patient and family will depend on the role and responsibility the patient has played in the family structure and on the family's coping mechanisms
2. Alterations in self-perception and body image related to vascular access devices and attachment to administration equipment for PN solution administration
3. Alterations in lifestyle, including catheter-related care, PN infusion and related requirements, social activity changes (most social activities revolve around eating), and potential financial impact
4. Readjustment of priorities and values, secondary to possible alterations in lifestyle, finances, and health-related considerations
5. Dependence on medical equipment and healthcare personnel
6. With children, home PN may interfere with normal developmental stages

D. Patient Education

1. Comprehensive curriculum for patient education is tailored to the needs of each individual
 - a. Verbal and written instructions of appropriate therapy-related procedures should be provided
 - b. The educational process should include demonstration of procedures followed by return demonstrations by the patient or primary caregiver
 - c. Evaluation of competency and instruction should be documented
2. Definition of therapy/indication for the treatment
3. Solution preparation in the home, including specific drug/nutrient information related to the admixture
4. Infusion administration procedures
 - a. Spiking container
 - b. Priming administration set/filter
 - c. Catheter connection
 - d. Use of electronic infusion device
5. Catheter maintenance
 - a. Dressing change procedure
 - b. Catheter complication monitoring
 - c. Catheter protection during bathing/swimming
 - d. Techniques for maintaining catheter patency: dose, volume, frequency, method used for drawing up, and injecting solution
6. Daily self-monitoring and significance of alterations
 - a. Notify the LIP if elevated temperature, chills, or sweats are experienced
 - b. Blood sugar monitoring: frequency is dependent on the stability of the patient; attempt to keep glucose <150 mg/dL
 - c. Weight gain/loss
 - 1) Measure at same time daily, with the patient wearing similar articles of clothing
 - 2) Expected weight gain or loss will vary with each patient, depending on rationale for therapy; weight gain therapy has an expected gain of approximately 0.5 to 1 pound/week; maintenance therapy is administered to maintain weight at a determined level
 - 3) Sudden losses or gains are indicators of fluid imbalance
 - d. Intake and output/decreased or excessive urine output
 - 1) Teach to monitor intake and output
 - 2) Ideally, total intake should be approximately 500 mL greater than the total output
 - 3) If patient experiences new or increased peripheral edema or urine output of <600 mL for two consecutive days, contact the LIP; may indicate dehydration or fluid retention
 - 4) Urine output >1,700 mL/day in the average adult usually means the patient is getting too much fluid
7. Instruction should be provided on how to manage emergencies (such as occluded catheters, broken catheters, blood back-up in tubing, and malfunctioning equipment and physical complications, such as air embolism) until the healthcare clinician can be contacted
8. Care and storage of supplies
 - a. Storage, refrigeration, and preparation of solution
 - b. Prescription verification

- c. Expiration verification
 - d. Visual inspection of solutions and supplies
 - e. Use of syringes, vials, and ampoules
 - f. Clean work area and place for storage
9. Disposal of supplies: use of puncture-resistant container and procedure for disposal

E. Solution Administration Regimens

1. Continuous
 - a. Continuous infusions at a steady rate, 24 hours/day, are not preferred for home infusion because of the limitations it places on the patient and caregiver
 - b. Continuous infusion is desirable for patients who cannot tolerate a dextrose load and who have difficulty tolerating large quantities of fluid
 - c. If the patient is ambulatory, portable infusion pumps should be considered to allow for activities of daily living
2. Cyclic
 - a. Most patients receiving PN at home prefer cyclic infusion and generally choose the evening and/or nighttime for their infusion
 - b. Promotes independence and a more ambulatory lifestyle
3. Supplemental infusions
 - a. May be appropriate for patients who have limited gut function and/or inadequate oral intake
 - b. Some insurance carriers may not reimburse for this type of therapy
4. Lipid emulsion delivery: may be administered concurrently by using a Y-connection below the filter on the administration set, or added directly to the PN solution (three-in-one)

BIBLIOGRAPHY

- ASPEN Board of Directors and The Clinical Guidelines Task Force. (2009). Guidelines for the use of parenteral and enteral nutrition in adult and pediatric patients. *Journal of Parenteral and Enteral Nutrition*, 33(3), 255–259. doi: 10.1177/0148607109333115.
- ASPEN Board of Directors and the Task Force on Parenteral Nutrition Standardization. (2007). ASPEN statement on parenteral nutrition standardization. *Journal of Parenteral and Enteral Nutrition*, 31(5), 441–448. doi: 10.1177/0148607107031005441.
- Atkinson, S. A. (2011). Defining the process of dietary reference intakes: Framework for the United States and Canada. *American Journal of Clinical Nutrition*, 94 (Supplement): 6555S–6557S. First published online June 15, 2011. doi:10.3945/ajcn.110.005728.
- Barber, J. R., Miller, S. J., Rollins C. J., & Sacks, G. S. (2007). Parenteral feeding formulations. In M. M. Gottschlich (Ed.), *The A.S.P.E.N. nutrition support core curriculum: A case-based approach to the adult patient* (pp. 277–299). Silver Spring, MD: ASPEN.
- Berger, M. M., Chiolerio, R. L., Rombeau, J. L., & Rolandelli, R. H. (2001). *Clinical nutrition: Parenteral nutrition* (3rd ed.). Philadelphia, PA: W. B. Saunders.
- Boitano, M., Bojak, S., McCloskey, S., McCaul, D. S., & McDonough, M. (2010). Improving the safety and effectiveness of parenteral nutrition: Results of a quality improvement collaboration. *Nutrition in Clinical Practice*, 25(6), 663–671.
- Delegge, M. H., & Ireton-Jones, C. (2007). Home care. In M. M. Gottschlich (Ed.), *The A.S.P.E.N. nutrition support core curriculum: A case-based approach to the adult patient* (pp. 725–739). Silver Spring, MD: ASPEN.
- Gura, K. M. (2009). Is there still a role for peripheral parenteral nutrition? *Nutrition in Clinical Practice*, 24(6), 709–717. doi: 10.1177/0884533609351318.
- Infusion Nurses Society. (2011). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S56, S91, S92.

- Krzywda, E. A., & Meyer, D. (2010). Parenteral nutrition. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 316–350). St. Louis, MO: Saunders/Elsevier.
- Kumpf, V. J., & Gervasio, J. (2007). Complications of parenteral nutrition. In M. M. Gottschlich (Ed.), *The A.S.P.E.N. nutrition support core curriculum: A case-based approach to the adult patient* (pp. 323–339). Silver Spring, MD: ASPEN.
- Kuwahara, T., Kaneda, S., Shimono, K., & Inoue, Y. (2010). Growth of microorganisms in total parenteral nutrition solutions without lipid. *International Journal of Medical Sciences*, 7(1), 43–47.
- Kuwahara, T., Shimono, K., Kaneda, S., Tamura, T., Ichihara, M., & Nakashima, Y. (2010). Growth of microorganisms in total parenteral nutrition solutions containing lipid. *International Journal of Medical Sciences*, 7(3), 101–109.
- Marra, A. R., Opilla, M., Edmond, M. B., & Kirby, D.F. (2007). Epidemiology of bloodstream infections in patients receiving long-term total parenteral nutrition. *Journal of Clinical Gastroenterology*, 41(1), 19–28.
- Mattox, T. W. (2008). Parenteral nutrition. In J. T. DiPiro, R. L. Talbert, G. C. Yee, et al. (Eds.), *Pharmacotherapy: A pathophysiological approach* (7th ed., pp. 2379–2397). Stamford, CT: Appleton & Lange.
- Miller, S. J. (2009). Commercial premixed parenteral nutrition: Is it right for your institution? *Nutrition in Clinical Practice*, 24(4), 459–469. doi: 10.1177/0884533609339067.
- Mirtallo, J. M. (2007). Overview of parenteral nutrition. In M. M. Gottschlich (Ed.), *The A.S.P.E.N. nutrition support core curriculum: A case-based approach to the adult patient* (pp. 264–276). Silver Spring, MD: ASPEN.
- Mirtallo, J., Canada, T., Johnson, D., Kumpf, V., Petersen, C., Sacks, G., ... Guenter, P. (2004). Safe practices for parenteral nutrition. *Journal of Parenteral Enteral Nutrition*, 28(6), S39–S70.
- Mirtallo, J. M., Dasta, J. F., Kleinschmidt, K. C., & Varon, J. (2010). State of the art review: Intravenous fat emulsions: Current applications, safety profile, and clinical applications. *Annals of Pharmacotherapy*, 44(4), 688–700. doi: 10.1345/aph.1M626.
- O'Grady, N.p., Alexander, M., Burns, L.A., Dellinger, E., Garland, J., Heard, S.O., ... Healthcare Infection Control Practices Advisory Committee. (2011). Guidelines for the prevention of intravascular catheter-related infections. *American Journal of Infection Control*, 39 (4 Supplement 1): S1–S34. doi: 10.1016/j.ajic.2011.01.003.
- Phillips, L. D. (2010). Nutritional support. In *Manual of I.V. therapeutics: Evidence-based practice for infusion therapy* (5th ed., pp. 789–848). Philadelphia, PA: F.A. Davis.
- Rollins, C. (2007). Drug nutrient interactions. In M. M. Gottschlich (Ed.), *The A.S.P.E.N. nutrition support core curriculum: A case-based approach to the adult patient* (pp. 340–359). Silver Spring, MD: ASPEN.
- Russell, M. C. (2007). Nutrition screening and assessment. In M. M. Gottschlich (Ed.), *The A.S.P.E.N. nutrition support core curriculum: A case-based approach to the adult patient* (pp. 163–188). Silver Spring, MD: ASPEN.
- Sansivero, G. E. (2010). Features and selection of vascular access devices. *Seminars in Oncology Nursing*, 26(2), 88–101. doi: 10.1016/j.soncn.2010.02.006.
- Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.). (2009). Guidelines for the provision and assessment of nutrition support therapy in adult critically ill patient. *Journal of Parenteral and Enteral Nutrition*, 33(3), 277–316. doi: 10.1177/0148607109335234.
- Ukleja, A., Freeman, K. L., Gilbert, K., Kochevar, M., Kraft, M. D., Russell, M. K., ... Shuster, M. H. (2010). Standards for Nutrition Support: Adult hospitalized patients. *Nutrition in Clinical Practice*, 25(4), 403–414. doi: 10.1177/0884533610374200.

Quality Improvement

Grace Fletcher, MSN, RN, CRNI®, CPHQ



I. Managing Quality

A. Key Concepts

1. Quality is the result of the commitment to achieving excellence
2. It is not a product of a single activity
 - a. A variety of behaviors and actions are involved that
 - 1) Occur on a continuum
 - 2) Occur at all levels of an organization
3. It seeks to improve outcomes by improving processes and structures
4. It cannot be “assured” but rather measured, managed, and improved on
5. Quality is a result that can be described subjectively and evaluated by
 - a. Comparison of actual outcomes against desired outcomes
 - b. Comparison of performance over time (stability)
6. Quality is challenging when providing high-volume, high-risk therapies
7. Quality or performance systems are designed to allow the organization to provide high-volume, high-risk therapies and services via competent expertise, knowledge, and appropriate assessment and monitoring

B. Defining and Perceiving Quality and Quality Models

1. Quality control
 - a. “On-line” inspection during manufacture or process implementation
 - b. Compares the product or service with a theoretical standard or model
 - c. Detects “defects” before use or dispensing to the consumer
2. Quality assurance (traditional)
 - a. Retrospective review of care through chart audit or other document review
 - b. Compares results data with an arbitrary and static “threshold”
 - c. Results in a pass versus fail determination
3. Quality assessment (QA)
 - a. Combines retrospective and concurrent review of care through observation and reviews
 - b. Monitors outcomes and customer perceptions/satisfaction

- c. Analyzes trends for variances
- d. Compares results data with a moving “threshold” based on trends and variability
- 4. Quality improvement (QI)
 - a. Builds upon the data or measurements obtained in QA
 - b. Uses that data to develop improvement priorities, plans
 - c. Evaluates the effectiveness of the improvement strategy via repeated data collection and measurement
- 5. Continuous quality improvement
 - a. Builds on the principles of QA/QI
 - b. Integrates full organization; not limited to “clinical” departments within the organization but includes administrative, financial, medical, and environmental control departments
 - c. Promotes and emphasizes multidisciplinary coordination and integration
 - d. Evaluates the full patient care experience with the facility or organization
- 6. Performance improvement (PI)
 - a. Differentiates between “quality” (subjective) and “performance” (specific and objective)
 - b. Recognizes that certain measurable elements of performance impact significantly the total patient experience
- 7. Total quality management (TQM)
 - a. Patient-focused strategic vision
 - b. Involves all levels of the organization from leadership down
 - c. Based on the concepts of Juran, Crosby, and Deming
 - d. Six Sigma and lean manufacturing are examples of TQM



II. Quality Improvement

A. Types of Standards

- 1. Performance standards
 - a. Overview
 - 1) Statements of expected quality and performance as defined by the organization
 - 2) Can be separated by “domains of care”: structures, processes, and outcomes
 - 3) Can be separated by “domains of organizational structure”: governance, practice, and care
 - b. Provide the framework for providing and monitoring the delivery of care and are:
 - 1) Value-driven, measurable, and achievable
 - 2) Combine individual, societal, institutional, and professional values
 - 3) Predetermined and regularly reviewed
 - 4) Written
 - 5) Approved by an authoritative body or entity
 - 6) Accepted by those individuals most affected
 - c. Provide a framework within which to define “variances,” “defects,” or unacceptable levels of performance
 - 1) Malpractice
 - 2) Product failure

- 3) Noncompliance
 - 4) Protocol failure
 - 5) Risk occurrences
- d. Provide a framework for resolving ethical conflicts between the health-care professional's duty to the patient and responsibilities as an employee within the healthcare organization
2. Classifications of standards by domains of care
 - a. Structure standards
 - 1) Describe conditions and mechanisms that support provision of care
 - 2) Include the mission, philosophies, and goals of the organization
 - 3) Environmental design, equipment, condition of environment of care
 - 4) Policies, procedures, protocols, and pathways that establish requirements
 - b. Process standards
 - 1) Describe activities and procedures provided during the provision of care
 - 2) Evaluate actual procedures provided versus written procedures
 - 3) Based on direct measurements or observations of the procedures as they occur
 - c. Outcome standards
 - 1) Describe the desired product or expected result of the provision of care
 - 2) Include clinical therapeutic outcomes, adverse events, and patient perceptions and satisfaction
 - 3) Can be expressed as measurement of negative events (i.e. phlebitis rates) or positive events (i.e. resolution of infection; improvement of pain level)
 - 4) Based on direct measurements or observations of the results of the care upon completion
3. Classifications of standards by organizational structure
 - a. Standards of governance
 - 1) Emphasize the role of the organizational leadership
 - 2) Evaluate the commitment of leadership to provide resources needed for patient care
 - 3) Emphasize the commitment of leadership to performance and QI
 - b. Standards of practice
 - 1) Emphasize the role of the organization's practitioners and care providers
 - 2) Emphasize the importance of accountability and competency
 - 3) Emphasize the use of professional research and national standards to establish acceptable practice within the organization
 - c. Standards of patient care
 - 1) Evaluate the sum total of the patient's experience
 - 2) Emphasize the outcome of the patient's experience
 - 3) Frequently are standards that require integration of all organizational levels and departments toward a common goal

B. Components of a Quality-Driven Organization/Program Design

1. Education
 - a. Staff
 - 1) Established minimum educational requirements for job categories
 - 2) Confirmation of educational backgrounds
 - 3) Ongoing job-based education and training in job tasks and information for patient care

- 4) Requirements for ongoing professional continuing education activity outside of employment
- 5) Involves active participation in programs and sharing of information with other healthcare professionals
- b. Patients and caregivers
 - 1) Established minimum teaching standards for procedures, treatment, therapies, and/or disease states
 - 2) Integration of educational standards and materials into the patient teaching process
 - 3) Validation of patient learning through interview or other competency validation
 - 4) Evaluation of patient teaching through patient/caregiver satisfaction measurement
- c. Leadership and staff regarding performance improvement
 - 1) Established educational plan for leadership and staff on principles of QA/QI and TQM
 - 2) Incorporates collection, translation, and use of data toward improvement
- d. Healthcare community
 - 1) Organization may participate in research and development to:
 - a) Support the use of an internal policy or protocol not supported in the medical literature
 - b) Improve patient care
 - c) Add to the existing scientific body of knowledge
 - 1) Participate in nursing research to advance the science of infusion nursing
- e. Orientation
 - 1) Familiarizes the nurse to
 - a) Organization and department structure
 - b) Policies, procedures, and practice guidelines
 - c) Accountability and autonomy
 - d) Communication and collaboration
 - 2) Reviews critical safety information
 - 3) Includes didactic and clinical ("hands on") education
 - 4) Requires competency validation (see Section IV)
 - 5) Should be documented on checklist or other organization-approved document
2. Policies, procedures, and other documents that guide care and services
 - a. Direct healthcare delivery within a specific organization
 - b. Identify acceptable courses of action for personnel
 - c. Should be:
 - 1) Reviewed annually
 - 2) Revised as necessary
 - 3) Representative of organizational and national standards and current evidence-based practices
 - d. Policy
 - 1) Based on state law, federal regulations, standards of practice, and state of the art in the practice area
 - 2) Defined as a course or statement of action
 - 3) Must be specific, concise, and clinically sound
 - 4) Must be achievable within the resources of the organization

- 5) Must be written and formally approved by the organization it is designed to serve
- 6) Must be circulated and revised as necessary
- 7) Must have associated documentation verifying annual review
- 8) Revised as necessary
- 9) Represents organizational standards
- 10) Reflects national standards and current evidence-based practice
- e. Procedure
 - 1) Based on state law, federal regulations, standards of practice, and the state of the art in the practice area
 - 2) Involves psychomotor skills performed by healthcare practitioners
 - 3) Reflects contemporary standards of practice
 - 4) Includes a series of precise steps that outline the recommended manner in which skills should be performed
- f. Practice guidelines/protocols/clinical pathways
 - 1) Typically multidisciplinary
 - 2) Direct clinical care decisions based on the current state of knowledge
 - 3) List important aspects of providing a specific treatment or using (or operating) equipment/device
 - 4) Incorporate Risk Evaluation and Mitigation Strategies (REMSs) as required by the Food and Drug Administration (FDA)
- g. Job descriptions
 - 1) Describe the duties and responsibilities within a particular role
 - 2) Further define tasks and activities necessary to fulfill a role successfully
 - 3) Clinically sound and performance based
 - 4) Provide for self-inventory (self-assessment)
 - 5) Address achievable behaviors and actions
 - 6) Stated in measurable terms using measurable statements
 - 7) Assist in the identification and resolution of performance problems
 - 8) Reviewed annually, revised as necessary with input from the employee
3. A formal structured model and process for performance and QI
 - a. Characteristics of an organization PI program
 - 1) It is described in written documents
 - 2) It is authorized and approved by the organization leadership
 - 3) It is ongoing, flexible, and continually active
 - 4) It incorporates the organization mission and goals
 - 5) It incorporates the expectations and needs of the patient
 - 6) It assists the organization in balancing the benefit and costs of provision of patient care
 - 7) It has similar elements as the nursing process in that it includes:
 - Assessment (of the organization)
 - Interventions (for improvement)
 - Evaluation of the effect of interventions (continued monitoring)
 - 8) Models typically are cyclic
 - PDSA (Plan—Do—Study—Act)
 - The Joint Commission (TJC) PI cycle
 - 9) It identifies the areas of needed improvement through review of
 - Data collection and analysis
 - Employee feedback and suggestions
 - Patient feedback and suggestions
 - Reviews of risk reports and other internal documents

- b. Measures
 - 1) Characteristics
 - a) Discreet elements of care or outcomes that can be systematically monitored
 - b) Are a direct indicator of the quality of services provided to the patient or the performance of an individual, department, program, or organization
 - c) May be specific to one department or may reflect activities involving some or all departments
 - (a) Example: compare the measure for “Waiting time from PICC prescription order to PICC insertion” (department specific) versus the measure “Central Venous Access Device Infection Rate” (organizational or global)
 - 2) Types
 - a) Incidence based (catheter phlebitis rates per 1,000 PICC catheter days)
 - b) Percentage based (percentage of patients that required more than one venipuncture for IV catheter insertion)
 - c) Measures of central tendency (average overall satisfaction rating with hospital stay on a 1 to 10 scale)
 - 3) Measure selection
 - a) Inter-departmental or intra-departmental based on the type of measure
 - b) Dictated by outside organizations (i.e. TJC, URAC [formerly known as Utilization Review Accreditation Committee])
 - c) “Core metrics” determined by governmental or other organizations; deemed significant metrics for all organizations of that type
- c. Data collection
 - 1) Data collected by interview, observation, or visual inspection
 - 2) Data collected by retrospective reviews of records or “real time” via computerized patient care documentation systems
 - 3) Documentation of patient care allows for data retrieval
- d. Data display graphics
 - 1) Display method based on data type
 - a) Run charts exhibit performance of a measure over time
 - b) Control charts exhibit performance of a measure over time, and stability or variability in data
 - c) Pareto and histograms (bar graphs) show distribution of data among categories or ranges
 - 2) Fishbone (Ishikawa) diagram
 - a) Typically used after sentinel events or “near misses”
 - b) Helps to determine the root causes of an actual or potential serious error
 - c) Points out the changes needed in procedures, equipment, training, or staffing
 - 3) Brainstorming
 - a) Used during system evaluation and redesign
 - b) Used during initial design of new projects or programs
 - c) Encourages creative flow of ideas
 - 4) Multi-voting
 - a) Narrows large lists of options or ideas into workable and reasonable numbers

- b) Prioritizes lists based on group consensus
 - c) Results in realistic and group-driven decision making
 - 5) Flow charts
 - a) Graphical representation of decision making and process using universal symbols
 - b) Help determine errors and problems with a process
 - c) Visually represent a manufacturing or service process from beginning to end
 - d) Help in illustrating the areas of responsibility
 - 6) Affinity diagram
 - a) Used after brainstorming activities
 - b) Used to organize large volumes of ideas or issues
 - 7) Data collection logs and tools
 - a) Frequently custom designed to capture specific pieces of information or data being studied
 - b) Can be paper or onscreen digital forms
 - c) Can include procedure logs, satisfaction surveys, or quality control/maintenance logs
 - 8) Outcomes data systems
 - a) Typically database-driven, though spreadsheets might be used
 - b) Frequently outsourced from a third party software vendor or outcomes management company
 - c) Collects organization-wide data on outcomes and patient satisfaction on a long-term basis
 - d) Can be integrated into the organization's computer/digital patient record
 - e) May be a separate data entry system for gathering and reporting outcome data and patient satisfaction data
- 4. Data translation/interpretation
 - a. Utilization of collected data as part of the overall evaluation of performance
 - b. Utilization of collected data to determine the potential root causes for data variances or failure to meet acceptable goals, thresholds, or benchmarks
 - c. Utilization of information gathering methods (brainstorming, root cause analysis, multivoting, flow charting) to guide the improvement process
- 5. Corrective action
 - a. Need for corrective action determined based on:
 - 1) Failure to meet an established benchmark or threshold
 - 2) A trend in data that indicates an instability or concern (i.e. gradually decreasing patient satisfaction)
 - 3) Occurrence of a sentinel event
 - 4) Occurrence of events that expose the organization to legal risk
 - b. Typically planned and implemented after data collection and data translation
 - c. May include:
 - 1) Retraining of personnel
 - 2) Re-evaluation of policies, procedures, and practice guidelines
 - 3) Re-evaluation of equipment or environmental design
 - 4) Re-evaluation of documentation
 - 5) Re-evaluation of data collection methodology
 - d. Action plans
 - 1) Should list individual tasks and steps

- 2) Should include target dates for completion
- 3) Should include designated team or staff members to whom tasks are assigned
- e. Follow-up evaluation
 - 1) Repeated data and information collection
 - 2) Should replicate original data or information collection performed prior to improvement
 - 3) Measures the effectiveness of the corrective actions implemented
 - 4) Determines if corrective actions (i.e. changes in policies, retraining, etc.) should be permanently adopted or abandoned.
 - a) If abandoned, corrective process continues with additional activities until improvement achieved



III. Legal Aspects and Risk Management of Infusion Nursing Practice

A. Overview

1. Reference to legal standards is an integral component of a QI program
2. Incorporation of legal standards is the basis of the organization's risk reduction or risk management program
3. Two types of laws pertinent to infusion therapy practice are criminal and civil
 - a. Criminal law involves an offense against the general public
 - 1) Primary emphasis defines behaviors prohibited or controlled by society as a whole
 - 2) Criminal offenses are prosecuted by a government authority
 - 3) May result in fines or imprisonment, or both
 - b. Civil law applies to the legal rights of private individuals or organizations; includes negligence or malpractice

B. Negligence

1. Defined as not performing an activity that a reasonable person would comparatively do in a similar situation
2. Carrying out an activity that a reasonable person would not in similar circumstances is considered to be negligent
3. Four elements necessary to prove negligence
 - a. The patient was owed a duty of care; the nurse in some way was responsible for the patient
 - b. Duty of care owed to the patient was breached
 - c. The cause of the injury must be proven to be the result of the negligent conduct
 - d. By law, the injury suffered allows for compensation
4. Malpractice is defined as negligent conduct on the part of a member of a recognized accountable profession
 - a. Further defined as a deviation from the professional standard of practice that a qualified healthcare practitioner in the identical area of practice would follow in a similar situation
 - b. May be considered synonymous with professional negligence because failure to act in a reasonable and prudent manner, as defined by the profession, may result in harm to the patient

- c. Denotes stepping beyond one's authority
 - 1) Nurse Practice Act defines scope of nursing practice
 - 2) Performing a procedure outside the boundaries of nursing practice may be ruled illegal and in violation of the state Nurse Practice Act
- d. Common areas of nursing malpractice
 - 1) Medication administration
 - 2) Failure to use equipment properly and safely
 - 3) Failure to communicate; for example, failing to notify the licensed independent practitioner (LIP) of a change in the patient's condition
 - 4) Failure to act; for example, failing to clarify an illegible order for parenteral medication and its administration
 - 5) Failure to monitor and assess clinical status
 - 6) Failure to prevent infection

C. Torts

- 1. Civil offense that occurs as a private wrong against another person or property
 - a. Result of private act or omission
 - b. Possibly intentional or unintentional (a result from an act of negligence)
 - c. May be differentiated based on the type of offense
- 2. Assault
 - a. Unjustifiable attempt to touch another person or the threat to do so; does not include actual physical contact
 - b. Example: a competent patient refuses to undergo venipuncture, but the nurse proceeds to assemble necessary equipment and prepares to perform the procedure
- 3. Battery
 - a. Unlawful carrying out of threatened physical harm
 - b. Physical contact without permission
 - c. Nurse applies the tourniquet and performs the insertion procedure without the permission of the competent patient
- 4. Coercion
 - a. Forcing a person to act in a certain manner
 - b. Involves threats or intimidation (assault)
 - c. Competent patient does not want a venipuncture and the nurse forces the patient into accepting the unwanted venipuncture (assault and battery)
- 5. False imprisonment
 - a. Act of placing an individual in a confined area against his or her will
 - b. Often involves restraints
 - c. Nurse must follow organizational policy when placing a restraint on a patient in an effort to preserve post-insertion integrity of a venipuncture site
- 6. Defamation
 - a. To harm one's reputation through false and/or malicious statements
 - b. Slander—oral defamation communicated by writing, television, radio, or similar medium
 - c. Libel—written defamation
- 7. Disclosure of confidential information
 - a. Act of providing private and confidential information concerning a patient and diagnosis, matters pertaining to his or her care, and prognosis to uninvolved persons
 - b. Absence of expressed patient permission

- c. Prohibited by the Health Insurance Portability and Accountability Act federal regulations
- 8. Rule of personal liability
 - a. Legal responsibility to fulfill an obligation
 - b. Each person is responsible for his or her own actions
 - c. The nurse is a knowledgeable professional, capable of independent judgment and actions inherent in professional nursing practice
 - d. The nurse's role in carrying out or questioning the LIP's orders has increased nursing autonomy and legal responsibilities
 - e. The nurse must be able to evaluate LIP orders as they apply to the patient and the intended plan of care
 - f. The nurse must question any order believed not to be in the patient's best interest before implementation

D. Regulating Agencies and Authoritative Bodies

- 1. Overview
 - a. Develop and implement mandates that indirectly or directly affect the role of the healthcare practitioner (infusion nurse)
 - b. Include federal, state, regulatory agencies and authoritative bodies and professional organizations
- 2. FDA
 - a. Controls testing, approval, manufacturing, labeling, and distribution of drugs, cosmetics, and medical devices
 - b. Determines if a medication carries sufficient risk to warrant REMS
 - 1) REMS include specific patient medication guides that must be provided, and can include specific practitioner competency validation, or patient monitoring and evaluation
 - c. Establishes requirements for reporting patient harm from equipment or drug-related malfunctions or events including:
 - 1) Malfunctioning patient care equipment (including infusion pumps)
 - 2) Transfusion-related deaths
 - 3) Faulty labeling or packaging
 - 4) Drug-related incidences
- 3. Occupational Safety and Health Administration
 - a. Establishes and enforces regulations to promote job safety and protect the health of workers
 - b. Promulgated the Bloodborne Pathogen Standard and Needlestick Safety Act, which includes the use of Standard Precautions, engineering controls, and exposure control plans
 - c. Employer is responsible for employee education and the ongoing monitoring of employee compliance
- 4. TJC
 - a. Voluntary, ongoing programs designed to ensure that healthcare organizations provide a high level of quality in patient care and health service delivery
 - b. Via "deemed status" can approve an organization as a Medicare-certified provider
 - c. Via "deemed status" can approve an organization as compliant with the DMEPOS Part B Supplier Quality Standards
- 5. State Regulatory Boards
 - a. State agencies establish policies regarding professional licensure (individual, facility)

- b. Establish position statement or opinion statements on specific procedures or elements of professional practice or facility operations/practice
- c. State Boards of Nursing are responsible for the development, implementation, and compliance of practice guidelines identified in the state Nurse Practice Act
 - 1) Define the practice of professional and licensed practical/vocational nursing within the specific state
 - 2) Delineate specific rules regarding how the nurse is allowed to legally participate within the profession
 - 3) Nurse practice act varies from state to state, ranging from broadly stated to detailed critical delineation
 - 4) Nursing Boards of Registration establish the minimal requirements for licensure to be met within the borders of a particular state and provide the basic entry mechanism for nursing practice
 - 5) State Board of Nursing is empowered by the state law to suspend or revoke the license of any nurse for violation of specific measures of professional conduct for the state

E. Professional Organizations/Associations

- 1. Infusion Nurses Society
 - a. Developed, reviews, and revises the *Infusion Nursing Standards of Practice*
 - 1) Reflect contemporary clinical principles and practices specific to infusion nursing
 - 2) Provide a basis for organization policies and procedures
 - 3) Applicable to all practice settings and patient populations
 - 4) Based on the best evidence and research available
 - b. Maintains a certification program through the Infusion Nurses Certification Corporation
 - 1) Purpose: patient/public protection
 - 2) Certification is the formal recognition of specialized knowledge, skills, and experience; a step beyond licensure
 - 3) Certified Registered Nurse Infusion designation; provides professional recognition and documentation of additional education and knowledge of infusion nursing
- 2. Other organizations
 - a. Examples
 - 1) AABB (formerly known as the American Association of Blood Banks)
 - 2) National Home Infusion Association
 - 3) Association for Professionals in Infection Control and Epidemiology
 - 4) American Society of Health-Systems Pharmacists
 - b. May collaborate on developing standards or guidelines to enhance the practice of infusion nursing

F. Organizational Risk Management Strategies

- 1. Policy manuals
 - a. Development based on:
 - 1) Law and regulation
 - 2) National professional standards
 - 3) Individual state requirements
 - 4) Accreditation standards
 - 5) Research and evidence of best practices

- b. Review of manual
 - 1) On a regular pre-determined basis
 - 2) By an authorized (designated) multidisciplinary group
 - 3) Using a consistent method to propose and approve changes
- c. Dissemination
 - 1) Made available to all users of the manuals in a consistent and acknowledged method
 - 2) May be digital or paper version
 - 3) Must reflect most current versions when used
- 2. Informed consent
 - a. A policy (structure) and a procedure (process) required by the healthcare organization to protect the patient and organization (risk reduction)
 - b. Includes the educational process during which the patient is given sufficient information to fully comprehend the procedure
 - c. Includes the intended consequences or expected outcomes of the procedure
 - d. Includes expectations of compliance and behavior of the patient during the procedure
 - e. Includes description of the treatment options
 - f. Criteria for appropriate consent
 - 1) The patient is capable of granting consent via authorized signature or via a legally recognized, approved, and associated third party
 - 2) There is absence of coercion witnessed by a third party
 - 3) It may be verbal
 - 4) Written agreement is necessary if determined by organizational policy
 - g. Emergency consent may be obtained when there is an immediate need for consent
 - h. Per organizational policy, a witnessed telephone or verbal consent may be valid within specified parameters and time constraints
 - 1) Obtain from a person legally authorized to give consent
 - 2) Assent to the procedure from teenagers and school-aged children obtained and documented; information tailored for knowledge and developmental level
 - 3) A minor child brought to the emergency department by someone other than the custodial parent; consent must be obtained from the legal guardian unless there is a life-threatening emergency
 - a) Increased awareness needed in today's era of blended or extended family units versus traditional families; a family member may not be the child's legal guardian; emancipated minor; child of a minor
 - i. Investigational therapies require special informed consent that is obtained by the principal investigator of a research study
- 3. Corporate Compliance Program
 - a. Provides a framework for ethical practice
 - b. Provides education to employees on compliance topics
 - c. Provides ongoing monitoring of the processes to assure compliance and ethical practice in:
 - 1) Patient care
 - 2) Billing
 - 3) Sales and marketing
 - d. Provides a framework to help make decisions in ethical dilemmas or dilemmas such as withholding or withdrawing care

4. Risk reporting
 - a. Encouraged through a “non-punitive” culture
 - b. Should include actual risk events and “near misses”
 - c. Must use a standard document (form) developed by legal and risk management personnel
 - d. Provides objective specific facts concerning an event that might result in risk exposure
 - e. Should include assessment of patient condition before the occurrence and results of immediate follow-up interventions
 - f. Should flag “sentinel” events for immediate action
 - g. Should flag needlestick injuries for immediate action
 - h. Should include adverse drug reactions and equipment failures to:
 - 1) Promote review of formulary of drugs and equipment
 - 2) Promote required reporting of incidents to the FDA (i.e. MedWatch)
 - 3) Integrate into FDA REMS requirements for specific medications
 - i. Must be reviewed by organization PI/QA Committee for trends and corrective actions
 - j. Is not referenced or included in the patient medical record
5. Documentation standards
 - a. Documentation provides a permanent record of the services provided so that the performance and the quality of the organization can be reviewed and evaluated
 - b. Provides a permanent record of the services provided as a strategy for reduction of risk and legal exposure/liability
 - c. Recorded as part of the patient’s permanent medical record
 - 1) Accurate, succinct description of care rendered to patient
 - 2) Legible and timely, including organization-approved abbreviations
 - 3) Initial and ongoing assessment, monitoring, and nursing intervention
 - 4) Reference to compliance with organizational protocols, policies, or procedures
 - 5) Communication of essential findings to LIPs and others involved in patient’s care
 - a) Vascular access device (VAD)
 - Type of catheter or device, including brand name
 - Location
 - Gauge and length
 - Date of insertion
 - Site care and condition, according to established intervals along with necessary interventions
 - Confirmation of anatomic location of catheter tip for all CVADs
 - b) Infusion prescription
 - Type of infusate and volume
 - Additives and amounts
 - Date and time of admixture
 - Rate
 - When multiple access devices/lumens, indication of what fluids and/or medications are infused via which device/lumen
 - Volume absorbed according to established intervals
 - c) Patient tolerance parameters
 - d) Use of ancillary/adjunctive infusion equipment, such as electronic or mechanical infusion devices

- e) Patient and caregiver education
- f) Nurse's signature
- d. Forms
 - 1) Must be approved for use by the healthcare organization if used for documentation of patient care
 - 2) Include:
 - a) Assessment forms
 - b) Prescription/order forms
 - c) Plans of care
 - d) Flow sheets and monitoring tools
 - e) Procedure check lists
 - f) Unusual occurrence report (risk reports)
 - g) QA data collection logs



IV. Infusion-Related Competencies

A. Competency Standards

1. Considered a "performance standard" (see Section II)
2. Establish standards for the knowledge and proficiency of the employee in job-related elements, tasks, or subjects

B. Competency-Based Education

1. Requires that employee education consider required competencies for patient care
2. Requires that critical patient care competencies be included in the objectives and outline of the education program
3. Requires that the employee (participant) be able to successfully demonstrate competency (demonstration of skill or successful completion of a test) at the completion of the education program

C. Competency Validation

1. Validation confirms and documents evidence of competency
2. Can include:
 - a. Confirmation of credentials, certifications, education, and prior experience
 - b. Confirmation of current licensure
 - c. Review of written/web-based tests for validation of knowledge
 - d. Observation of the correct completion of tasks
3. Validation at established pre-determined intervals as per organization policies
4. Must be documented and maintained in employment records
5. Must include priority focus area ("high risk") for patient protection

D. Certification

1. Certification or credentialing on national level
 - a. Method for regulating and protecting specialized practitioners
 - b. Identification of a healthcare professional practicing on a higher, more advanced level than determined by licensure
 - c. Method for ensuring expert quality healthcare delivery to the public

2. Provides opportunities for recertification
 - a. Mechanism or documentation tool for re-evaluating and updating skills and competencies
 - b. Continued adherence to organizational policies and procedures in compliance with federal and state regulatory laws and the nursing specialty's national standards for care/practice
3. Requirements for recertification
 - a. Documentation of ongoing education
 - b. Proof of current licensure
 - c. Validation of clinical experience and current active credentials within specific practice area

BIBLIOGRAPHY

- Alexander, M. C., & Webster, H. K. (2010). Legal issues of infusion nursing. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 49–59). St Louis, MO: Saunders/Elsevier.
- Alexander, R., O'Malley, A. A., & Androwich, I. M. (2008). Evidence-based health care. In P. Kelly (Ed.), *Nursing leadership & management* (2nd ed., pp. 110–126). Clifton Park, NY: Thomson Delmar Learning.
- American Board of Nursing Specialties. (2005). *A position statement on the value of specialty nursing certification*. Retrieved from http://www.nursingcertification.org/pdf/value_certification.pdf.
- Brent, N. J. (2005). The use and misuse of electronic patient data. *Journal of Infusion Nursing*, 28(4), 251–257.
- Burkhardt, M. A., & Nathaniel, A. (2008). *Ethics and issues in contemporary nursing* (3rd ed.). Clifton Park, NY: Thomson Delmar Learning.
- Counce, J., & Prosser, B. (2011). Practicing ethical decision-making in alternate-site infusion. *Infusion*, 17(6), 24–32.
- Garst, R. (2010). Continuous performance improvement: Getting extraordinary results from ordinary data. *Infusion*, 16(1), 18–23.
- Infusion Nurses Society. (2011). Infusion nursing standards of practice. *Journal of Infusion Nursing*, 34(1 Supplement), S1–S110.
- Itano, J. K., & Taoka, K. N. (Eds.) (2005). *Core curriculum for oncology nursing* (4th ed.). Philadelphia, PA: W. B. Saunders.
- The Joint Commission. (2012). *2012 Comprehensive accreditation manual for home care*. Oakbrook Terrace, IL: Joint Commission Resources.
- Mensick, J. S. (2011). Understanding research and evidence-based practice: From knowledge generation to translation. *Journal of Infusion Nursing*, 34(3), 174–178. doi: 10.1097/NAN.0b013e3182134f44
- Miller, R. D. (2006). *Problems in health care law* (9th ed.). Rockville, MD: Aspen Publications.
- Phillips, L. D. (2010). *Manual of I.V. therapeutics: Evidence-based practice for infusion therapy* (5th ed.). Philadelphia, PA: F. A. Davis.
- Rappa, E., & Ness, S. (2011). Balancing medication access and risk: What the FDA's REMS programs mean for infusion pharmacy. *Infusion*, 17(6), 16–23.
- Sierchio, G. M. (2010). Quality management. In M. Alexander, A. Corrigan, L. Gorski, J. Hankins, & R. Perucca (Eds.), *Infusion nursing: An evidence-based approach* (3rd ed., pp. 22–48). St Louis, MO: Saunders/Elsevier.

Index

Page numbers followed by a "t" denote tables; Page numbers followed by a "f" denote figures

A

AAA. *See* Aromatic amino acids

ABGs. *See* Arterial blood gases

ABO blood group, 235–236

antibodies of, 236t

antigens of, 236t

in hemolytic disease of the newborn, 220

Absolute neutrophil count (ANC), 263

Access, alternative

arterial, 73–75

intraosseous, 81–82

intraspinal, 75–80

subcutaneous tissue, 82–83

Access ports

add-on devices, 166–167

on administration sets, 166

care and maintenance of, 183

Acetate salts, 336

Acetone, 181

Acid–base balance

metabolic acidosis, 91, 103–104, 115–116

metabolic alkalosis, 93, 116–117

overview of, 115

pediatric

in adolescents, 192

in infants, 192

in neonates, 193–194

in premature neonates, 192–193

in preschoolers, 195

in school age children, 195

in toddlers, 194

respiratory acidosis, 117–118

respiratory alkalosis, 118

Acidosis

diabetic ketoacidosis, 128

metabolic, 91, 103, 148, 115–116

respiratory, 117–118

Acquired Immune Deficiency Syndrome (AIDS)

in children, 230

and nutritional status, 272

Acrocyanosis, 203

Activase (alteplase), 154

Active transport, 87

Activity, physical

of children, 199

energy expenditure of, 228

and replacement fluids, 217

Activity factors (AF), 315

Acute respiratory distress syndrome, 328

Acute transfusion reactions, 245–249

allergic, 247

anaphylaxis, 247–248

bacterial contamination, 248–249

citrate toxicity, 249

febrile nonhemolytic, 246

hemolytic, 245–246

hypothermia, 249

potassium toxicity, 249

transfusion-associated circulatory

overload, 248

transfusion-related acute lung injury, 246–247

Acyclovir sodium, 143

Adapters, vented spike, 14

Add-on devices

administration sets and, 45–46

care and maintenance of, 70

connectors, 19–20

extension sets, 19

injection/access ports, 166

needleless connectors, 20, 46

purpose, 19

solid caps, 20

stopcocks, 19, 215

transducers and domes, 74

vented spike adapters, 14

Adenocard (adenosine), 150

Adenosine, 150

ADH (antidiuretic hormone), 88, 99, 218

Administration. *See also* Administration sets

of analgesia, 77

of anesthesia, 77

of antineoplastic therapy, 266–268

of blood products, 253–256

documentation of, 36, 255, 361, 366, 369

of drugs, 134–137

equipment for pediatric patient, 207–208

of lipid emulsions, 344, 346, 354

of parenteral nutrition, 341–346, 351–354

patient education for, 353

rates for, 16, 32, 132, 223

vein selection for, 36–37, 74, 210–211

- Administration sets, 15–18
 - and add-on devices, 45–46
 - for blood/blood products, 253
 - characteristics and features, 16–18
 - clamps, 17
 - clinical considerations of use, 18
 - construction of, 15–16
 - cultures of, 190
 - drop factor of, 16
 - for fat emulsions, 346
 - injection/access ports, 17
 - internal administration set diameter, 17
 - materials, 15
 - nursing considerations, 18
 - for parenteral nutrition, 345
 - for pediatric use, 208
 - selection of, 25
 - set change frequency, 45–46
 - types of, 15–16
- Admixtures
 - bacterial contamination of, 166
 - total nutrient, 338–339
- Adolescents, 195, 197. *See also* Children
- Adrenal gland, 88
- Adrenalin (epinephrine hydrochloride), 148
- Adriamycin (doxorubicin hydrochloride), 279
- AF (activity factors), 315
- Affinity diagrams, 362
- Age of patient
 - in fluid balance, 89
 - in pharmacologic therapy, 132
 - in site selection, 36–37
- Agencies, regulatory, 167, 365–366
- Agglutinins, 235
- Agranulocytes, 164
- AIDS. *See* Acquired Immune Deficiency Syndrome
- Air embolism, 60–61, 209
- Air vents, 16, 23, 50
- Air-dependent containers, 14
- Alarms on infusion devices, 29
- Albumin
 - plasma expanders, 119, 126, 124
 - serum, 331–332
- Aldesleukin (interleukin-2), 290
- Aldomet Ester Hydrochloride (methyldopate hydrochloride), 151
- Aldosterone, 88, 95, 129
- Alemtuzumab, 290
- Alimta (pemetrexed), 285
- Alkalinizing solutions, 126
- Alkalosis
 - metabolic, 93, 116–117
 - respiratory, 118
- Alkylating agents, 273
- Allen's test, 74
- Allergic reactions
 - to blood products, 247
 - to medications or solutions, 64
- Allergies, 132, 199
- Alloimmunization, 250
- Alopecia, 296
- Alteplase, 154
- Amicar (aminocaproic acid), 153
- Amikacin sulfate, 139
- Amikin (amikacin sulfate), 139
- Amino acids, 315, 334
- Aminocaproic acid, 153
- Aminoglycosides, 139
- Aminopenicillin, 137
- Aminophylline (theophylline ethylenediamine), 160
- Ammonium chloride, 156
- Amphotericin B, 142
- Ampicillin sodium, 137
- Amrinone lactate, 149
- Anabolism, 318, 333, 347
- Analgesia
 - agents for, 144
 - epidural, 78
 - intraspinous, 75–76
 - intrathecal, 76, 78
 - intraventricular, 76
 - transdermal cream, 27
- Anaphylactic reactions, 239, 275
- Anemia
 - with antineoplastic therapy, 269–270
 - sickle cell, 226–227
- Energy testing, 332–333
- Anesthesia
 - epidural, 78
 - local, 212
- Anions, 111
- Annulus, 2
- Anorexia, 270–271
- Antagonist hematologic agent, 153–154
- Antecubital fossa, veins in, 37
- Anterior longitudinal ligament, 10
- Anthropometric measurements, 131
- Antiarrhythmic agents, 149–150
- Antibiotics
 - aminoglycosides, 139–140
 - antifungals, 142–143
 - antiprotozoals, 143–144
 - antitumor, 260
 - aztreonam, 140
 - cephalosporins, 138–139
 - chloramphenicol sodium succinate, 140
 - clindamycin phosphate, 140–141
 - colistimethate sodium, 141
 - daptomycin, 141
 - erythromycins, 140
 - linezolid, 141

- ointments, 174, 181, 209
- penicillins, natural, 137
- quinupristin/dalfopristin, 141
- quinolone, 140
- rifampin, 141
- sulfonamide combination, 144
- tetracyclines, 139
- vancomycin hydrochloride, 141
- Antibodies
 - defined, 235
 - monoclonal, 290, 298
- Anticholinergic agent, 152
- Anticonvulsants, 145–146
- Antidiuretic hormone (ADH), 88, 99, 218
- Antiemetics, 158
- Antifungals, 142–143
 - azoles, 142
 - echinocandins, 142–143
 - polyenes, 142
- Antigens, 235, 236t
- Anti-infective agents, 137–144
 - aminoglycosides, 139–140
 - aminopenicillin, 137
 - antifungals, 142
 - antiprotozoals, 143–144
 - carbapenems, 139
 - cephalosporins, 138–139
 - erythromycins, 140
 - macrolides, 140
 - penicillins, natural, 137–138
 - quinolone, 140
 - sulfonamide combination, 144
 - tetracyclines, 139–140
- Antimetabolites, 259, 273
- Antimicrobial preparations, 180–181
- Antineoplastic agents
 - asparaginase, 274
 - bleomycin, 275
 - carboplatin, 265, 275–276
 - carmustine, 276
 - cisplatin, 108, 276
 - cyclophosphamide, 276–277, 283
 - cytarabine, 277
 - dacarbazine, 277–278
 - dactinomycin, 278
 - daunorubicin hydrochloride, 278
 - docetaxel, 279
 - doxorubicin hydrochloride, 279
 - doxorubicin liposome injection, 279–280
 - etoposide, 280
 - fluorouracil, 281, 283
 - gemcitabine, 281
 - ifosfamide, 282, 283
 - irinotecan, 282, 291
 - mechlorethamine hydrochloride, 283
 - methotrexate, 272, 283–284
 - mitomycin C, 284
 - mitoxantrone hydrochloride, 284
 - paclitaxel, 18, 281, 285
 - streptozocin, 286
 - thiotepa, 286
 - topotecan, 286
 - vinblastine, 287
 - vincristine, 287
 - vinorelbine, 287
- Antineoplastic and biologic therapy
 - administration of, 266–268
 - antineoplastic agents for, 274–287
 - biologic agents in, 306–307
 - caregiver and patient education, 265–266, 306
 - cell cycle in, 258–259
 - clinical assessment, 262–263
 - complications of, 268, 306–308
 - compounding, 267
 - drug specificity in, 259–260, 306
 - evaluation of diagnostic findings, 263–264
 - goals of the treatment, 264
 - infusion programs for, 267
 - investigational agents and protocols, 260–261
 - irritants, 265
 - patient history, 261–262
 - patient information in, 295
 - personnel in, 266
 - pharmacologic categories, 273–274
 - preadministration considerations, 261–266
 - side effects/toxicities, 269–273
 - treatment orders, 264–265
 - type of cancer, 264
 - vascular access in, 265, 266
 - vein selection in, 345
 - vesicants, 265
- Antiprotozoals, 143–144
- Antithrombin III, 133, 153
- Antitumor antibiotics, 260, 273
- Antivirals, 143
- Anxiolytics, 72, 145
- Aortic semilunar valves, 2
- Apnea, 202
- Appetite, 330, 351
- Apresoline (hydralazine hydrochloride), 152
- Aquamephyton (phytonadione), 161, 223
- Arachnoid mater, 11
- Aranesp (darbepoetin alfa), 154
- Aromatic amino acids (AAA), 315
- Arsenic trioxide, 274
- Arterial access
 - assessment relative to therapy, 73
 - catheter care and maintenance, 74
 - catheter removal, 75
 - complications, 75
 - equipment, 74
 - follow-up care, 75

- Arterial access (*continued*)
 - indications for, 73
 - site selection, 74
- Arterial blood gases (ABGs), 95, 206
- Arterial catheters
 - removal of, 74, 185
 - selection of, 185
- Arterial pressure monitoring sets, 73, 78
- Arterial puncture, inadvertent, 66
- Arterial spasm, 57–58, 75
- Arteries
 - advantages/disadvantages of use, 4
 - characteristics of, 3
 - layers of, 3
 - location of, 3
 - nerve conduction in, 3–4
 - for vascular access, 4
- Ascorbic acid (vitamin C), 325
- Asparaginase, 274
- Assault, 364
- Assessments of patients
 - for antineoplastic therapy, 305–306
 - for fluid and electrolyte status, 329
 - during infusions, 195
 - for initiation of infusion therapy, 33–34
 - nutritional, 329–333
 - of pain, 211–212
 - for patient education, 34–36
 - in pediatrics, 198–207
 - for pharmacologic therapy, 132
 - in site selection, 36–37
 - to terminate therapy, 80
 - for transfusions, 252–253
- AT-III (antithrombin III), 153
- Ativan (lorazepam), 145, 270
- Atria, 2
- Atrioventricular (AV) node, 2
- Atrioventricular (AV) valves, 2
- Atropine sulfate, 147
- Autologous transfusion, 237
- Autonomic nervous system, 12
- Avastin (bevacizumab), 290
- AV node, 2
- AV valves, 2
- Axillary node dissection, 36
- Azactam (aztreonam), 140
- Azacytidine, 274–275
- Azathioprine sodium, 160
- AZT (zidovudine), 143
- Aztreonam, 140
- B**
- Back-check valves, 16
- Bacteremia. *See* Septicemia
- Bacterial infections. *See* Infections
- Bacterial organisms
 - in catheter-related infections, 169–170, 172
 - in contamination, 167–169
 - lifespan/multiplication in solutions, 169
 - resident flora, 172
 - transient flora, 172
- Bacterial phlebitis, 55, 186
- Bactrim (co-trimoxazole), 144
- Bag-entry ports, 50
- Balloons, elastomer, 31, 136
- Basal energy expenditure (BEE), 314
- Basal metabolic rate (BMR), 313–314
- Basilic veins, 5, 6, 26
- Basophils, 163–164
- Battery, 364
- BCAA (branched-chain amino acids), 315, 327, 334
- BCNU (carmustine), 276
- BEE (basal energy expenditure), 314
- Bendamustine, 275
- Beta-blocking agents, 151
- Betalin S (thiamine hydrochloride), 161
- Bevacizumab, 290
- Bicarbonate, 115, 156
- Biliary atresia, 233–234
- Biliary tract obstruction, 327
- Bilirubin, 206
- Biologic therapy
 - infusion reactions with, 306–307
 - overview of, 297, 306
- Biotherapy in cancer treatment, 288
- Biotin, 324
- Bladder elimination, in children, 199
- Bleeding disorders
 - hemophilia, 228
 - in site selection, 40
- Blenoxane (bleomycin), 275
- Bleomycin, 275
- Blood administration pressure cuff, 39, 255
- Blood cultures, 190
- Blood disorders, 226–234
- Blood filters, 21–23, 183, 254–255
- Blood gases, 132–133, 210, 213, 263
- Blood glucose. *See* Glucose
- Blood groups, 235–236, 236t
- Blood pressure (BP), 144, 195
- Blood transfusions. *See* Transfusions
- Blood typing, 240
- Blood urea nitrogen (BUN), 94, 133, 263, 350
- Blood volume
 - in adolescents, 195
 - in infants, 194
 - in neonates, 193
 - in preschoolers, 195
 - in school age children, 195
 - in toddlers, 194
- Blood warmers, 253, 255

Blood/blood components. *See also* Transfusions
 administration, 253–256
 administration sets for, 15, 183, 255
 blood warmers for, 254, 255
 contamination of, 169, 170, 248–249
 cryoprecipitate, 241–242, 255
 cultures of, 230
 documentation of, 255–256
 Factor VIII concentrate, 243
 Factor IX concentrate, 243
 filters for, 21–23, 183, 254
 fresh frozen plasma, 240
 orders for, 253
 platelets, 240–241
 red blood cells, 238–240
 storage of, 254
 whole blood, 237–238
 Bloodborne pathogen exposure control, 178
 BMR (basal metabolic rate), 313–314
 Body composition, 86
 Body fluids. *See* Fluids, body
 Body surface area (BSA)
 calculating, 136, 200, 214, 264
 of children, 249, 251
 adolescents, 195
 infants, 194
 neonates, 194
 premature neonates, 192
 preschoolers, 195
 school age children, 195
 toddlers, 194
 Body water content
 in adolescents, 195
 in infants, 194
 in neonates, 193
 in premature neonates, 192
 in preschoolers, 195
 in school age children, 195
 in toddlers, 194
 Body weight. *See* Weight, body
 Bone resorption inhibitors, 161
 Bones
 functions and shapes of, 21
 intraosseous administration, 21
 intraosseous catheters, 80, 173, 208
 intraosseous needles, 21, 81, 208
 Bortezomib, 292
 Bowel function. *See* Gastrointestinal function
 BP. *See* Blood pressure
 Brachial plexus, 11, 66
 Brachial veins, 41
 Brain, anatomy and physiology of, 8–9
 Branched-chain amino acids (BCAA), 315, 327, 334
 Brevibloc (esmolol hydrochloride), 151
 BSA. *See* Body surface area
 Buffering agents, 115

Bumetanide, 156
 Bumex (bumetanide), 156
 BUN (blood urea nitrogen), 94, 133, 263, 350
 Bundle branches of heart, 3
 Bundle of His, 3
 Bupivacaine hydrochloride, 77, 146
 Buprenex (buprenorphine hydrochloride), 144
 Buprenorphine hydrochloride, 144
 Burns
 and energy expenditures, 314
 and fluid and electrolyte balance, 129
 and nutritional status, 325
 parenteral nutrition for, 328–329

C

Calcium
 and cardiac function, 128
 in children, 193, 205
 hypercalcemia, 106–107
 hypocalcemia, 105–106
 nutritional requirements for, 319–320
 overview of, 105
 Calcium channel blocking agents, 150–151
 Calcium chloride, 155
 Calcium gluconate, 104, 155
 Calculations
 of absolute neutrophil count, 164
 of body surface area, 136, 200, 214, 264
 of drug dosages, 136, 214, 264
 of energy expenditures, 314
 of fluid requirements, 215
 of infusion flow rate, 16
 Calorie-to-nitrogen ratios, 340
 Calorimetry, 315
 Campath (alemtuzumab), 290
 Camptosar (irinotecan), 282, 291
 Cancer. *See also* Antineoplastic therapy
 cell development in, 259
 drug specificity for, 259
 leukemia, 231
 neuroblastoma, 232–233
 and nutritional status, 328
 Wilms' tumor, 231–232
 Cancer cachexia, 328
Candida sp.
 in catheter-related infections, 169, 170, 171
 in endogenous contamination, 168
 in extrinsic contamination, 166
 in intrinsic contamination, 167
 and parenteral nutrition, 346
 in septicemia, 188, 189
 Capillaries, 7
 Capillary refill, 204
 Caps, solid, 20
 Carbapenems, 139

- Carbohydrates
 - nutritional requirements for, 317–318
 - parenteral solutions, 333, 334–335
- Carboplatin, 265, 275–276
- Cardene (nicardipine), 151
- Cardiac failure, 326
- Cardiac function
 - and antineoplastic treatment, 264, 288
 - and calcium, 128
 - circulation in, 1–3
 - in fluid and electrolyte balance, 127–128
 - homeostatic mechanisms of, 219
 - and magnesium, 108–110
 - and nutritional status, 326
 - and phosphate, 111–113
 - and potassium, 102–104
- Cardiac valves, 2
- Cardiotonic agents, 149
- Cardiotoxicities, 272
- Cardiovascular agents, 147–153
- Cardizem (diltiazem), 151
- Care plan, 132
- Carmustine, 276
- Catabolism, 317, 318, 333
- Catheter embolism, 61–62
- Catheter-associated venous thrombosis, 69–70
- Catheter-related infections
 - causative factors of, 61
 - insertion site in, 42, 172–173, 179
 - means of contamination, 166–169
 - and parenteral nutrition, 346–347
 - predisposing factors of, 172
 - prevention of, 184–186
 - risk factors for, 347
 - treatment of, 190–191
- Catheters
 - antimicrobial/antiseptic Impregnated, 182
 - for antineoplastic therapy, 266–267
 - arterial, 74–75, 185
 - care of, 181–184, 351
 - central vascular access devices, 25–27
 - complications of, 48–73
 - after catheter removal, 46
 - central venous catheters, 173, 182
 - local, 49–59, 346
 - systemic, 59–64
 - contamination of, 166, 346, 347
 - cultures of, 190
 - damaged, 71
 - defined, 24
 - dislodgment of, 76
 - double-lumen, 24
 - dressing protocols for, 182–183
 - epidural, 76
 - flushing, 44–45
 - implanted ports, 47–48, 71
 - intraosseous, 80, 173, 208
 - intrathecal, 75–80
 - locking, 45
 - midline, 24, 47
 - migration of, 70
 - multilumen, 67
 - occluded, 62, 353
 - over-the-needle, 24
 - for parenteral nutrition, 346, 347
 - for pediatric use, 23–25
 - percutaneous, 25
 - peripheral, 24–25
 - peripherally inserted central catheter (PICC), 25
 - placement of, 39, 54, 69, 70, 173
 - removal of, 74, 185
 - rupture of, 62
 - single-lumen, 26
 - site care, 43–44
 - site preparation, 38, 41–42
 - for transfusions, 254
 - tunneled, 25, 26, 41, 77, 347
 - umbilical, 208–209
 - ventricular reservoir, 79–80
- Catheter stabilization devices, 21
- Cations, 103
- CBC (complete blood count), 133
- Cefazolin sodium, 138
- Cefepime hydrochloride, 138
- Cefotan (cefotetan disodium), 138
- Cefotaxime sodium, 138
- Cefotetan disodium, 138
- Cefoxitin sodium, 138
- Ceftazidime, 138
- Ceftriaxone sodium, 138
- Cefuroxime sodium, 138
- Cell cycle, 258–259
- Cell cycle-nonspecific agents, 260
- Cell cycle-specific agents, 259
- Cellulitis, 187–188
- Central alpha agonist, 151
- Central infusion therapy
 - infusion site selection in children, 210
 - veins for, 6
- Central nervous system agents
 - analgesics, 144
 - antagonists, 144–145
 - anticonvulsants, 145–146
 - atropine sulfate, 147
 - bupivacaine, 146
 - dantrolene sodium (Dantrium), 146
 - dexmedetomidine hydrochloride (Precedex), 146
 - droperidol (Inapsine), 146
 - promethazine hydrochloride (Phenergan), 147
 - propofol (Diprivan), 147
 - sedatives, hypnotics and anxiolytics, 145

- Central PN. *See also* Parenteral nutrition
 administration equipment for, 345–346
 administration sets for, 345–346
 bacterial contamination of, 346–347
 cyclic regimens, 342–343
 defined, 309
 discontinuation of, 342
 electrolyte imbalances with, 347–348
 emotional and psychosocial issues of, 352
 filters for, 21
 indications for, 311
 initiation of, 341
 nitrogen supplementation during, 317
 rate of delivery, 342
 solution formulas for, 339–340
- Central vascular access devices (CVAD)
 access for parenteral nutrition, 345
 complications of, 64–73
 after removal, 69
 arterial puncture, 66
 brachial plexus injury, 66
 cardiac tamponade, 72–73
 catheter migration, 70–71
 catheter site infection, 68
 CVAD site infection, 68
 damaged catheter, 71–72
 dislodgment and Twiddler's syndrome, 69–70
 extravascular malposition, 67
 fibrin formation with occlusion, 72
 hemothorax, 65
 hydrothorax, 65–66
 intravascular malposition, 67–68
 in parenteral nutrition, 346
 Pinch-off syndrome, 69
 pneumothorax, 64–65
 superior vena cava syndrome, 72
 venous thrombosis, 69
 composition of, 26
 configuration of, 26
 contamination of, 166, 346, 347
 and extravasation, 54
 gauge and length of, 39
 indications for, 40
 insertion techniques for, 39
 local anesthesia, 42
 lumens, 26
 for pediatric use, 208
 placement of, 26, 42
 properties of, 25
 removal of, 25
 selection of, 41, 180
 site preparation, 41–42
 site selection, 40–41
 types of, 25
- Central venous catheter (CVC). *See* Central vascular access devices
- Central venous pressure, 92
- Cephalic veins, 5, 6, 345
- Cephalosporins, 138–139
- Cerebellum, 9
- Cerebrospinal fluid (CSF), 9
- Cerebrum, 8
- Cerebyx (fosphenytoin sodium), 146
- Certification, 369–370
- Cerubidine (daunorubicin hydrochloride), 278
- Cervical nerves, 11
- Cervical plexus, 11
- Cetuximab, 290
- Chelating agents, 154–155
- Chemical incompatibilities of drugs, 135
- Chemical phlebitis, 54–55, 186
- Chemistry panel, 133
- Chemotherapy regimens, 264. *See also*
 Antineoplastic therapy
- Children
 biliary atresia in, 233–234
 body surface area of, 136, 200, 214, 264
 cystic fibrosis in, 224–225
 electrolyte balance in, 192–195
 fluid balance in, 192
 hemolytic disease of the newborn in, 220–221
 hemophilia in, 228–229
 HIV and AIDS in, 230–231
 hypoglycemia in, 221–222
 laboratory studies of, 205–207
 leukemia in, 231
 medical history of, 198–200
 meningitis in, 225–226
 necrotizing enterocolitis in, 229–230
 neuroblastoma in, 232–233
 pain management in, 211–212
 parenteral nutrition for, 312–313, 339, 353
 pharmacology in, 213–214
 physical examination of, 330–331
 physiologic development of, 192–195
 protein requirements for, 316
 psychosocial development of, 195–198
 pyloric stenosis in, 221
 salicylate intoxication in, 223
 sickle cell anemia in, 226
 skin turgor in, 91, 204
 transfusions in, 237
 venipuncture in, 210–211
 Wilms' tumor in, 231–232
- Chloramphenicol sodium succinate, 140
- Chlorhexidine gluconate, 180
- Chloride
 in children, 193, 205
 hyperchloremia, 114
 hypochloremia, 114
 nutritional requirements for, 319
 overview of, 116

- Chloromycetin sodium succinate
(chloramphenicol sodium succinate), 140
- Chloroprocaine, 77
- Chlorothiazide sodium, 156
- Cholestasis, 349
- Christmas disease, 243
- Chromium, 322
- Chronic obstructive pulmonary disease, 328
- Chvostek's sign, 93
- Cimetidine hydrochloride, 157
- Circulation
- arteries in, 3–7
 - blood flow in, 3–7
 - capillaries in, 7
 - cardiac, 1–3
 - pulmonary, 3
 - systemic, 3–7
 - veins in, 4–7
- Circulatory overload, 248
- Cisplatin, 108, 276, 281
- Citrate toxicity, 249
- Citrobacter freundii*, 170
- Citrovorum factor (leucovorin calcium), 283
- Civil offenses, 364
- Claforan (cefotaxime sodium), 138
- Clamps, 17
- Cleocin phosphate (clindamycin phosphate),
140–141
- Clindamycin phosphate, 140–141
- Closed system containers, 14
- Coagulation disorders. *See* Bleeding disorders
- Coccygeal nerves, 12
- Coercion, 364
- Cognitive-perceptual patterns, 199
- Colloid solutions, 124–126
- Coly-Mycin M (Colistimethate sodium), 141
- Compatibility of medications, 135, 344–345
- Complications
- after catheter removal, 75
 - allergic reactions, 64, 247
 - alloimmunization, 250
 - alopecia, 271
 - altered reproductive function, 273
 - anaphylaxis, 247–248, 307
 - anemia, 269–270
 - anorexia, 270–271
 - of antineoplastic therapy, 297, 269–273
 - arterial puncture, 66
 - arterial spasm, 75
 - bacterial contamination, 68–69, 347
 - brachial plexus injury, 66
 - cardiotoxicities, 272
 - catheter migration, 70
 - of central venous catheters, 64–73
 - cholestasis, 349
 - circulatory overload, 248
 - citrate toxicity, 249
 - constipation, 271
 - cytomegalovirus, 251–252
 - damaged catheter, 71
 - dehydration, 350
 - of dextrose solutions, 121, 122
 - diarrhea, 271
 - dislodgment of catheter, 69–70
 - ecchymosis, 50–51
 - EFAD, 319, 349
 - effects of, 48–49
 - electrolyte imbalances, 347
 - embolism
 - air, 60–61
 - catheter, 61–62
 - pulmonary, 60
 - extravasation, 51–54, 268, 346
 - extravascular malposition, 67
 - fluid imbalances, 350
 - gallbladder disease, 349
 - graft-vs-host disease, 251
 - hematoma, 50–51
 - hemothorax, 65
 - hepatitis, 251
 - human T-cell lymphotropic virus, 251
 - hydrothorax, 65
 - hyperglycemia, 348
 - hyperlipoproteinemia, 349
 - hyperosmolar syndrome, 348
 - hypoglycemia, 349
 - hypothermia, 249
 - infections
 - bacteremia, 59–60
 - at catheter site, 68
 - local, 187
 - opportunistic, 251
 - with parenteral nutrition, 346–347
 - peripheral site infection, 57
 - septicemia, 59–60, 188, 291
 - infiltration, 51–53, 346
 - inspection for, 43
 - intravascular malposition, 67
 - iron overload, 250
 - mechanical, 49–50
 - metabolic, 347–350
 - mucositis, 271
 - nausea and vomiting, 270
 - nephrotoxicity, 272
 - neurotoxicity, 272
 - neutropenia, 269
 - occlusion, 56–57, 25, 346, 353
 - ocular toxicity, 273
 - ototoxicity, 272
 - pancreatitis, 326
 - pericardial tamponade, 72
 - phlebitis, 54, 56, 346

- pneumothorax, 64
 - pulmonary edema, 62–63
 - refeeding syndrome, 347
 - septic, 346–347
 - septicemia, 59–60, 188, 291
 - sexuality, altered, 273
 - speed shock, 63–64
 - superior vena cava syndrome, 72
 - systemic, 59–64
 - technical, 346
 - therapeutic incompatibilities, 135
 - thrombocytopenia, 269
 - thrombophlebitis, 187, 346
 - thrombosis, 7, 69
 - trace element deficiencies, 348
 - of transfusions, 245–249
 - Twiddler's syndrome, 69
 - venous spasm, 57–58
 - vitamin deficiencies, 349
 - Component recipient set, 255
 - Compounding solutions, 341
 - Confidentiality, 364
 - Connectors, 18
 - Consent, informed
 - for infusion therapy, 36
 - for investigational agents and protocols, 261
 - legal aspects of, 363
 - for transfusions, 253
 - Constipation, 271
 - Containers. *See* Solution containers
 - Contamination
 - of blood products, 248–249
 - documentation of, 168
 - endogenous, 168
 - exogenous, 168
 - extrinsic, 166–167
 - at insertion site, 42, 172–174
 - intrinsic, 167–168
 - means of, 166–169
 - microorganisms involved in, 166–170
 - of parenteral solutions, 346
 - prevention of, 166–167, 168–169
 - reporting, 168
 - and septicemia/bacteremia, 59–60, 188, 347
 - Continuing education, 359
 - Continuous quality improvement (CQI), 357
 - Controlled volume administration sets, 15, 208
 - Controllers, mechanical, 33, 207
 - Controls on infusion devices, 36
 - Conus medullaris, 9
 - Conversions, unit, 136
 - Coping, 199
 - Copper, 322
 - Corrective action, 362–363
 - Corticosteroids, 89, 159
 - Cortisol, 88
 - Corvert (ibutilide fumarate), 150
 - Corynebacterium* sp., 167
 - Cosmegen (dactinomycin), 278
 - Co-trimoxazole, 144
 - CQI (continuous quality improvement), 357
 - Cranial nerves, 11
 - Creatinine, 94
 - Crohn's disease, 362
 - Cryoprecipitate, 241–242, 255
 - Crystalline amino acid, 169
 - Crystalloid solutions, 120–124
 - Cubicin (daptomycin), 141
 - Cultures, bacterial, 189–190
 - CVC (central venous catheter). *See* Central vascular access devices
 - Cyanosis, 203
 - Cyclic regimens
 - benefits of, 342
 - contraindications for, 343
 - description of, 342
 - for home parenteral nutrition, 354
 - indications for, 343
 - initiation of, 343
 - monitoring, 343
 - termination of, 343
 - Cyclophosphamide, 276, 283
 - Cyclosporine, 159
 - Cystic fibrosis, 224–225
 - Cytarabine, 277
 - Cytomegalovirus (CMV), 251–252
 - Cytosar-U (cytarabine), 277
 - Cytosine arabinoside, 277
 - Cytovene (ganciclovir sodium), 143
 - Cytosan (cyclophosphamide), 276–277
- D**
- Dacarbazine, 277–278
 - Dacogen (decitabine), 278–279
 - Dactinomycin, 278
 - Daptomycin, 141
 - Darbepoetin alfa, 154
 - Data retrieval, collection, and analysis, 361
 - Daunorubicin hydrochloride, 278
 - Decitabine, 278–279
 - Dedicated administration sets, 16
 - Deferoxamine mesylate, 154, 250
 - DEHP (di(2-ethylhexyl) phthalate), 208
 - Dehydration
 - and body temperature, 201
 - hypertonic, 216
 - hypotonic, 218
 - isotonic, 216–217
 - with parenteral nutrition, 350

- Delayed transfusion reactions
 - alloimmunization, 250
 - cytomegalovirus, 251–252
 - graft-vs-host disease, 251
 - hepatitis, 251
 - human T-cell lymphotropic virus, 251
 - iron overload, 251
 - opportunistic infections, 251
 - transfusion-related immunomodulation, 252
- Delivery rates. *See* Rate of delivery
- Demerol (meperidine hydrochloride), 144
- Depth filter, 22
- Dermis, 8
- Desferal (deferoxamine mesylate), 154, 250
- Dextran, 124–125, 157
- Dextrose
 - defined, 364
 - solutions, 121–122
 - 5% dextrose in lactated Ringer's, 124
 - 5% dextrose in Ringer's injection, 123
 - for hypoglycemia, 222
 - microorganism lifespan/growth in, 169
 - for parenteral nutrition, 334–335
- Dextrose/saline solutions, 344
- Diabetes insipidus, 100, 128
- Diabetes mellitus, 128–129, 165, 327
- Diabetic ketoacidosis, 111, 128
- Diarrhea, 271
- Diazepam (Valium), 145
- Diffusion, 87
- Diffucan (fluconazole), 142
- Digital veins, 5, 210
- Digoxin (Lanoxin), 149
- Dilaudid (hydromorphone hydrochloride), 144
- Diltiazem (Cardizem), 151
- Diluents, 135
- Direct calorimetry, 315
- Discharge planning, 351–352
- Disease status of patient, 89, 120–121, 132
- Dislodgment of catheter, 70–71
- Disposal
 - of hazardous waste, 179
 - of supplies, 354
- Diuretics, 89, 97
- Diuril (chlorothiazide sodium), 156
- Dobutamine hydrochloride, 148
- Dobutrex (dobutamine hydrochloride), 148
- Docetaxel, 279
- Documentation
 - of blood administration, 255
 - of contamination, 168
 - electronic, 132
 - of extravasation, 51
 - flow sheet for, 369
 - of infiltration, 54
 - of infusion therapy, 43
 - legal aspects of, 363
 - medication administration record, 54
 - of parenteral nutrition, 351
 - of patient education, 36
 - of performance improvement, 357
 - of septicemia/bacteremia, 59
 - of termination of therapy, 47–48
- Domes, 74
- Dopamine hydrochloride, 147–148
- Dosages
 - of antineoplastic agents, 274
 - calculating, 136, 214, 214
- Double-lumen catheters, 24
- Doxil (doxorubicin liposome injection), 279–280
- Doxorubicin hydrochloride, 279
- Doxorubicin liposome injection, 279–280
- Doxycycline hyclate, 139–140
- Dressings
 - changing, 44
 - gauze, 39, 44, 182
 - protocols for, 182
 - transparent semipermeable membrane, 39, 182
- Drop factor, 16
- Drop sensors, 29
- Droperidol, 146, 158
- Drug library, 29–30
- Drugs
 - administration of, 134–137, 166, 213–214
 - calculations, 136–137
 - compatibility, 135
 - containers, 135
 - forms, 134
 - methods of IV drug administration, 136
 - preparation, 134
 - stability, 135
 - admixing, 135, 166
 - adverse reactions to, 368
 - antineoplastic agents, 259, 274–287
 - calculations for, 136–137
 - for catheter-related infections, 190
 - classifications of
 - anti-infective agents, 137–144
 - cardiovascular agents, 147–152
 - central nervous system agents, 144–147
 - electrolyte and water balance agents, 155–157
 - gastrointestinal agents, 157–158
 - hematologic agents, 153–155
 - hormone and synthetic substitutes, 158–159
 - immune modulator agents, 159–160
 - respiratory smooth muscle relaxants, 160
 - vitamins, 160–161
 - compatibility of, 131, 135, 344–345
 - containers for, 135
 - errors with, 138
 - expiration dates of, 131
 - forms of, 134

- improperly mixed or diluted, 54
 - investigational agents, 132, 260
 - and nutritional status, 329
 - patient education about, 297
 - patient history of, 123, 124
 - pediatric use of, 198, 213–214
 - preparation of, 134
 - specificity of, 259–260
 - stability of, 135
 - DTIC (dacarbazine), 277–278
 - Dura mater, 8, 11, 78
- E**
- Eating disorders, 329
 - Ecchymosis, 50–51
 - ECF. *See* Extracellular fluid
 - Eculizumab, 290–291
 - Edecrin sodium (ethacrynate sodium), 156
 - Edema
 - assessment of patient for, 62, 133
 - in children, 204
 - and fluid status, 91
 - pitting, 96
 - pulmonary, 62–63
 - short cap, 72
 - Education, continuing, 359
 - Education, patient
 - about medications, 133
 - about parenteral nutrition, 351–354
 - documentation of, 36
 - evaluation of, 35
 - learner assessment, 35
 - overview of, 34
 - teacher assessment, 35
 - teaching plan, 35
 - teaching protocols for, 35
 - EFAD (essential fatty acid deficiency), 319
 - EID. *See* Electronic infusion devices
 - ELA Max, 212
 - Elastomeric device, 31, 136
 - Elderly
 - fluid status in, 89
 - skin turgor in, 36, 91
 - Electrolytes
 - agents for balancing, 155–157
 - in children, 205
 - infants, 193
 - neonates, 193
 - premature neonates, 192, 216
 - preschoolers, 197, 203
 - school age children, 197, 203
 - toddlers, 193, 203
 - imbalances of
 - calcium, 105–108
 - chloride, 113–114
 - magnesium, 108–110
 - phosphate, 111–113
 - potassium, 101–105
 - sodium, 98–101
 - in nutritional assessment, 329
 - nutritional requirements for, 314–325
 - prior to infusions, 123
 - solutions, 123, 124, 336
 - Electronic infusion devices (EID), 29–30
 - for parenteral nutrition, 345
 - for pediatric use, 207–208
 - for transfusions, 207
 - Ellence (epirubicin), 280
 - Eloxatin (oxaliplatin), 285–286
 - Elspar (asparaginase), 274
 - Embolism
 - air, 60–61
 - catheter, 61–62
 - pulmonary, 60
 - EMLA (eutectic mixture of lidocaine-prilocaine anesthetic), 212
 - Emotional needs
 - of adolescents, 197
 - of infants, 196
 - of neonates, 195
 - during parenteral nutrition, 351–354
 - of preschoolers, 197
 - of school age children, 197
 - of toddlers, 196
 - Endocrine system
 - in fluid and electrolyte balance, 128–129
 - homeostatic mechanisms of, 219
 - Endogenous contamination, 168–169
 - Energy
 - balance of, 314
 - basal energy expenditure, 314
 - energy expenditure of activity, 315
 - requirements for, 314–315
 - resting metabolic expenditure, 314
 - total daily energy expenditure, 314
 - Enterobacter* sp.
 - in catheter-related contamination, 170
 - in extrinsic contamination, 166
 - in intrinsic contamination, 167
 - lifespan/growth in solutions, 169
 - in septicemia/bacteremia, 59
 - Enterococcus* sp., 170
 - Enterocolitis, necrotizing, 229–230
 - Eosinophils, 164
 - Epidemiology, defined, 163
 - Epidermis, 8
 - Epidural analgesia, 76–77, 78
 - Epidural anesthesia, 76–77
 - Epidural space, 76
 - Epinephrine hydrochloride, 148

- Epirubicin, 280
Epoetin alfa, 288
Epogen (epoetin alfa), 288
Equipment
 add-on devices, 19–20, 45
 administration sets, 15–18, 45–46, 183
 arterial pressure monitoring sets, 73, 78
 bacterial contamination of, 57
 for blood and fluid, 254, 255
 catheters, peripheral, 24–25
 electronic infusion devices, 29–30, 207–208, 255, 342–343
 failures of, 368
 filters, 21–23, 183
 flow-control devices, 29–30
 hemodynamic monitoring sets, 73
 mechanical infusion devices, 30
 needles, 23–24, 81, 134
 for parenteral nutrition, 207–208
 personal protective, 175–176
 pumps
 implanted, 32
 for pediatric use, 214–215
 piston, 33
 positive pressure infusion, 31–32
 syringe, 33, 214, 215
 volumetric, 32–33
 solution containers, 14, 46
 for transfusions, 254–255
Erbitux (cetuximab), 290
Errors, medication, 131
Erythroblastosis fetalis, 220
Erythromycin lactobionate, 140
Erythromycin, 140
Escherichia coli, 169, 170, 339
Esmolol hydrochloride, 151
Esophageal disorders, 325
Essential amino acids, 315
Essential fatty acids, 318
 deficiency of (EFAD), 319, 349
Essential macronutrients, 333. *See also* Electrolytes
Essential micronutrients, 321–325
Ethacrynate sodium, 156
Etidocaine, 77
Etoposide, 280
Exchange transfusion, 220
Exercise. *See* Activity, physical
Exogenous contamination, 168
Expiration dates of drugs, 134
Extension sets, 19
External jugular vein, 6
Extracellular fluid (ECF)
 in adolescents, 197
 in body fluids, 94, 96
 in infants, 196
 in neonates, 195
 in premature neonates, 192
 in toddlers, 196
Extravasation, 51–54
 assessment for, 52–53
 causes, 51
 definition of, 51, 346
 documentation of, 54
 interventions for, 53–54
 monitoring statistics of, 54
 and parenteral nutrition, 346
 preventive measures for, 53–54
 reporting, 54
 risk factors, 52
 signs and symptoms of, 53
Extravascular hemolytic transfusion reactions, 239
Extravascular malposition, 67
Extrinsic contamination, 166–167
Eye disorders, 273
Eyewear, 41
- F**
- Face masks, 168
Factor VIII
 concentrate, 241
 deficiency of, 228, 243
Factor IX
 concentrate, 243
 deficiency of, 228
Factor XI deficiency, 228
False imprisonment, 364
Family
 medical history of, 200
 and parenteral nutrition, 351
Famotidine, 157
Fat
 functions of, 318
 metabolism of, 318
 in parenteral solutions, 333
 requirements for, 318
 types of, 318
Fat emulsions
 adverse reactions, 336
 caloric value, 335
 composition of, 335
 contraindications, 336
 dosage, 336
 osmolarity, 335
 tolerance, 336
Fatty acids, essential, 318
FDA (Food and Drug Administration), 365
Febrile nonhemolytic transfusion reactions, 239
Femoral artery, 4
Femoral vein, 7
Fentanyl citrate, 144

- Fibrin formation, 24
- Fight or flight reaction, 12
- Filgrastim, 288
- Filter needles, 22, 134
- Filters
 - add-on, 22
 - for blood products, 169
 - complications of, 50
 - depth filter, 22
 - features of, 21
 - filter needles, 22, 134
 - hollow fiber, 22
 - indications for use of, 22–23
 - in-line, 21
 - for intravenous solutions, 22
 - membrane filter, 22
 - nursing considerations, 23
 - for parenteral nutrition, 22, 346
 - particulate matter filters, 22
 - for pediatric use, 208
 - preparation of, 134
 - pressure limitations of, 21
 - to prevent phlebitis, 54
 - structural configuration of, 22
 - surface area of, 22
 - types of, 21–22
- Filtration, 87
- Fishbone diagrams, 361
- Flagyl I.V. (metronidazole hydrochloride), 143
- Flow charts, 362
- Flow rate. *See* Rate of delivery
- Flow-control devices, 28–33
 - electronic infusion devices, 29–30, 207–208, 255, 342, 343
 - features of, 30–31
 - implanted pumps, 32
 - indications for use, 30
 - mechanical infusion devices, 31–32
 - mechanisms of delivery, 28–29
 - nursing considerations for, 32–33
- Fluconazole, 142
- Fludara (fludarabine), 280–281
- Fludarabine, 280–281
- Fluid challenge test, 98
- Fluid volume deficit (FVD)
 - assessment of, 200
 - in children, 200, 216–219
 - defined, 96, 216
 - etiology of, 97
 - hypertonic dehydration, 216
 - hypotonic dehydration, 218
 - isotonic dehydration, 216–217
 - nursing interventions for, 98
 - and parenteral nutrition, 350
 - signs and symptoms of, 97–98
 - treatment of, 98
- Fluid volume excess (FVE)
 - in children, 220–221
 - description of, 95
 - etiology of, 95, 219
 - nursing interventions for, 96
 - and parenteral nutrition, 350
 - prevention of, 221
 - signs and symptoms of, 96, 220–221
 - treatment of, 96, 221
- Fluid volume imbalances, 95–98, 215–219
- Fluid warmers, 254, 255
- Fluids, body
 - in acute injury, 319
 - in body composition, 86–89
 - in children, 215–234
 - disease states affecting, 118
 - and electrolyte balance, 88
 - extracellular, 86, 87, 192, 219, 291, 319
 - fluid compartments, 86–87
 - fluid shifts, 95, 238
 - function and distribution, 86–88
 - homeostatic mechanisms for, 88–89
 - and hyponatremia, 99, 100
 - imbalances of, 94, 95–98, 350
 - inability to excrete, 95
 - intake and output of, 94, 97, 99, 351
 - interstitial, 87
 - intracellular, 86–87, 192, 194, 195
 - intravascular, 87
 - loss of, 86, 94, 237
 - in nutritional status, 329
 - and parenteral nutrition, 319, 350
 - patient assessment of, 89–95
 - patient education of, 353–354
 - requirements for, 319
 - and starvation, 319
 - transportation, 87
 - water balance agents, 155–157
- Fluids, replacement
 - alcohol solutions, 42
 - alkalinizing solutions, 126
 - in children, 215
 - dextrose solutions, 121
 - dextrose/saline solutions, 344
 - electrolyte solutions, 101, 119, 123, 124
 - equipment for, 255
 - overview of, 217
 - plasma expanders, 124
 - premixed solutions, 127
 - selection parameters for, 123
 - sodium chloride solutions, 121
 - tonicity of, 119–120
- Fluorouracil, 281, 291
- Flushing, 44–45
- Folic acid, 160, 325
- Follicular hyperkeratosis, 330

Folvite (folic acid), 160
 Fontanel, 204
 Food and Drug Administration (FDA), 365
 Forearm, veins in, 210
 Forms, 369
 Fortaz (ceftazidime), 138
 Foscarnet sodium, 143
 Foscavir (foscarnet sodium), 143
 Fosphenytoin sodium, 146
 Fresh frozen plasma, 240
 Frontal lobe of the brain, 8
 Frontal vein, 7
 Fructose, 317, 355
 5-FU (fluorouracil), 281, 291
 Fungal infections
 catheter-related, 169, 170
 and parenteral nutrition, 346–347
 and septicemia/bacteremia, 59, 75
 Fungizone (amphotericin B), 142
 Furosemide, 156
 FVD. *See* Fluid volume deficit
 FVE. *See* Fluid volume excess

G

Gallbladder disease, 326, 349
 Ganciclovir sodium, 143
 Garamycin (gentamicin sulfate), 139
 Gastroenteritis, 222–223
 Gastrointestinal agents, 157–158
 Gastrointestinal function
 and antineoplastic therapy, 270
 in cystic fibrosis, 224
 in fluid and electrolyte balance, 127
 and magnesium, 108
 in necrotizing enterocolitis, 229–230
 and nutritional status, 325–326
 in pyloric stenosis, 221
 Gauze dressing, sterile, 44, 47, 182
 G-CSF (granulocyte colony stimulating factor), 288
 Gemcitabine, 281
 Gemzar (gemcitabine), 281
 Gene therapy, 289–290
 Genitourinary system, 262
 Gentamicin sulfate, 139
 Glands
 adrenal, 88
 parathyroid, 88, 250
 pituitary, 87
 thyroid, 89
 Gloves, 175
 Glucagon hydrochloride, 159
 Gluconeogenesis, 318
 Glucose
 in children, 206

 defined, 317
 metabolism of, 318
 monitoring, 350–351, 353
 and nutritional status, 332
 and parenteral nutrition, 348–351, 353
 solutions of, 122
 for treatment of hyperkalemia, 158
 in urine, 206
 Glucose tolerance, 350–351
 Glycerol, 317, 335
 Glycogenesis, 318
 Glycogenolysis, 318
 Glycolysis, 318
 Gowns, disposable, 175–176
 Graft *vs.* host disease (GVHD), 251
 Gram-stains, 189
 Granulocyte colony stimulating factor (G-CSF), 288
 Granulocytes, 244–245
 Gray matter, 9–10
 Greater saphenous vein, 7, 211
 Growth burden, 259
 Growth measurements, in children, 200
 Gums, 331
 GVHD (graft *vs.* host disease), 251

H

Hair
 and nutritional status, 330
 removal of, 179
 Hand hygiene, 174
 Hand veins, 92, 133
 Harris-Benedict equation, 315
 Hazardous waste disposal, 354
 Health insurance, 365
 Health status of patient, 132, 305
 Heart, 1–2. *See also* Cardiac function
 Heartbeat, defined, 2
 Height, 185, 257, 381
 Hematocrit, 132, 206
 Hematogenous seeding, 165, 171
 Hematologic agents, 153–155
 Hematologic disorders
 with antineoplastic therapy, 269–270
 hemolytic disease of the newborn, 220–221
 hemophilia, 228–229
 sickle cell anemia, 226–227
 Hematoma, 50–51
 Hemoconcentration, 242, 243
 Hemodilution, 96
 Hemodynamic monitoring sets, 73
 Hemoglobin, 205–206, 333
 Hemolytic disease of the newborn, 220–221
 Hemolytic transfusion reactions, 245–246

- Hemophilia, 228–229
 - Hemorrhage, 97
 - Hemothorax, 65
 - Heparin sodium, 153
 - Hepatic failure, 250, 317, 340
 - Hepatic system, 129
 - and antineoplastic treatment, 269
 - in children, 194–195
 - and fluid and electrolyte balance, 129
 - and nutritional status, 250
 - and parenteral nutrition, 349
 - Hepatitis, 251
 - Herceptin (trastuzumab), 291
 - Hespan (hetastarch), 125, 156–157
 - Hetastarch, 125, 156–157
 - Hexa Betalin (pyridoxine hydrochloride), 160
 - Histamine antagonists, 338
 - HIV. *See* Human immunodeficiency virus
 - HLA-matched platelets, 241
 - Hodgkin's disease, 275–277, 279–280, 283
 - Hollow fiber filter, 22
 - Home parenteral nutrition
 - discharge planning, 351–352
 - emotional and psychosocial issues of, 352–353
 - patient education, 353–354
 - rationale for, 351
 - solution administration regimens, 354
 - Homeostatic mechanisms, 88–89
 - Hormone and synthetic substitutes, 158–159
 - Host defense, 163
 - HTLV (human T-cell lymphotropic virus), 251
 - Human immunodeficiency virus (HIV), 143, 295
 - Human leukocyte antigen (HLA) matched
 - platelets, 241
 - Human T-cell lymphotropic virus (HTLV), 251
 - Hycamtin (topotecan), 286
 - Hydralazine hydrochloride, 152
 - Hydromorphone hydrochloride, 144
 - Hydrops fetalis, 220
 - Hydrothorax, 65
 - Hyperbilirubinemia, 206
 - Hypercalcemia, 106–107
 - Hyperchloremia, 114
 - Hypercoagulability, 228
 - Hyperglycemia
 - and dextrose solutions, 221
 - and diabetes mellitus, 129
 - and hyperkalemia, 103
 - and nutritional status, 332
 - and parenteral nutrition, 333, 349
 - Hyperinsulinism, 122
 - Hyperkalemia, 103–104
 - Hyperkeratosis, follicular, 330
 - Hyperlipoproteinemia, 349
 - Hypermagnesemia, 110
 - Hypernatremia, 100–101
 - Hypernatremic dehydration, 217–218
 - Hyperosmolar syndrome, 348
 - Hyperphosphatemia, 112
 - Hypersensitivity testing, 332
 - Hypertension, pregnancy-induced, 129
 - Hypertonic dehydration, 216
 - Hypertonic solutions, 120
 - Hypervolemia
 - in children, 99
 - description of, 98
 - etiology of, 99
 - nursing interventions for, 100
 - and parenteral nutrition, 350
 - signs and symptoms of, 99
 - treatment of, 99
 - Hypnotics, 145
 - Hypoalbuminemia, 286, 313, 326
 - Hypocalcemia, 105–106
 - Hypochloremia, 114
 - Hypoglycemia
 - in children, 222
 - and nutritional status, 332
 - with parenteral nutrition, 343, 348–349
 - Hypokalemia, 101–102
 - Hypomagnesemia, 108–109
 - Hyponatremia, 99–100
 - Hyponatremic dehydration, 218–219
 - Hypoparathyroidism, 105, 113
 - Hypophosphatemia, 111–112, 320, 340
 - Hypothermia, 249
 - Hypotonic dehydration, 218–219
 - Hypotonic solutions, 119
 - Hypovolemia
 - assessment of, 89, 91
 - in children, 216–217
 - description of, 96
 - etiology of, 97
 - hypertonic dehydration, 217–218
 - hypotonic dehydration, 218–219
 - isotonic dehydration, 216–217
 - nursing interventions for, 98
 - and parenteral nutrition, 350
 - signs and symptoms of, 97–98
 - treatment of, 98
- I**
- Ibutilide fumarate, 150
 - Identification of patient, 34, 253
 - IF (injury factors), 315
 - Ifex (ifosfamide), 282, 283
 - Ifosfamide, 282, 283
 - Immune globulin IV, 159
 - Immune modulator agents, 159–160
 - Immune system, 163–164

- Immunocompetence testing, 332
- Immunohematology, 235–236
- Immunological testing (Immunocompetence testing), 332
- Immunostimulants, 159
- Immunosuppressants, 159–160
- Immunotherapy, 233
- Implanted ports, 25–26
 - for antineoplastic therapy, 170
 - dressing protocols for, 181
- Implanted pumps, 32
- Implanted vascular access devices, 25, 209
- Imprisonment, false, 364
- Imuran (Azathioprine sodium), 160
- Inapsine (droperidol), 146, 158
- Incompatibilities of medications, 135
- Inderal (propranolol hydrochloride), 151
- Indirect calorimetry, 315
- Infants. *See also* Children
 - body surface area of, 136, 200, 214, 264
 - fluid and electrolyte balance in, 89
 - nutrition in, 198
 - pain management in, 212
 - parenteral solution formulas for, 340
 - physiologic development of, 193–194
 - psychological development of, 196
 - skin turgor in, 36, 91
 - tearing and salivation in, 91
- Infection prevention
 - antimicrobial preparations in, 180–181
 - of bloodborne pathogens, 179
 - catheter care in, 181–182
 - catheter-related infections, 170–171, 181, 182–184
 - diagnostic methods for, 189–190
 - epidemiology and host defense in, 163
 - infusion complications, 134
 - insertion site contamination, 42, 172–173
 - means of contamination, 181–184
 - microorganisms in IV solutions, 171–180
 - safety compliance, 174–175
- Infections
 - bacterial phlebitis, 55, 186
 - catheter-related
 - causative factors of, 186
 - insertion site in, 172–174
 - means of contamination, 166–169
 - microorganisms involved in, 167, 168, 169–171
 - predisposing factors of, 186
 - prevention of, 184
 - treatment of, 190
 - local, 187–188
 - opportunistic, 251
 - and parenteral nutrition, 346–347
 - septicemia/bacteremia, 59, 60, 188, 347
- Infiltration
 - assessment for, 52–53
 - calculating rate of, 54
 - causes, 51
 - complications of, 53
 - definition of, 51
 - differential diagnosis of, 51
 - documentation of, 54
 - interventions for, 53
 - and parenteral nutrition, 346
 - preventive measures for, 53
 - risk factors, 52
 - scale, 52f
 - signs and symptoms of, 51
- Inflammatory bowel disease, 326
- Informed consent
 - for infusion therapy, 36
 - for investigational agents and protocols, 261
 - legal aspects of, 363
 - for transfusions, 253
- Infusion control devices
 - electronic, 29–30, 207–208, 255, 345
 - features of, 30–31
 - implanted pumps, 32
 - indications for use, 30
 - mechanical, 231–32
 - mechanisms of delivery, 28–29
 - for parenteral nutrition, 345
 - for pediatric use, 207–208
- Infusion Nurses Society (INS), 366
- Infusion Nursing Standards of Practice*, 18, 20, 184, 366
- Infusion rates. *See* Rate of delivery
- Infusion site. *See* Site, insertion
- Infusion therapy. *See also* Complications
 - add-on devices for, 19–20, 45
 - administration sets for, 15–18, 45–46, 183
 - of antineoplastic agents, 345
 - arteries for, 3
 - of blood products, 253–256
 - catheter and site care in, 43
 - catheter placement in, 42
 - catheter selection for, 41
 - catheters for, 40–42
 - in children, 207–208
 - via central VAD, 40–42
 - documentation of, 48
 - dressing changes in, 44
 - filters for, 21–23
 - flow-control devices for, 28–33
 - flushing, 44–45
 - follow-up to, 44
 - locking, 45
 - needles for, 23–24
 - of parenteral nutrition, 341–344
 - patient assessment in, 43

patient preparation in, 34
via peripheral VAD, 36–40
site care, 43
site preparation for, 38
site selection for, 36–37
solution containers for, 14
veins for, 5–7, 211

Injectable anesthetics, 212

Injection/access ports
add-on devices, 166–167
on administration sets, 17–18
care and maintenance of, 183

Injuries
brachial plexus injury, 66
and energy expenditures, 314
fluid changes with, 89, 319

Injury factors (IF), 315

In-line calibrated chamber method, 206–207

In-line filters, 21

Inocor lactate (amrinone lactate), 149

Institutional Review Boards (IRB), 260

Insulin, 158, 338, 348

Insurance, health, 365

Integumentary system. *See also* Skin
and antineoplastic treatment, 262, 296
of children, 193–194

Interleukin-2, 290

Intermediate basilic vein, 5

Intermediate cephalic vein, 5

Internal administration set diameter, 17

Internal jugular vein, 6

Interspinous ligament, 10

Interstitial fluid, 87

Intestinal disorders. *See* Gastrointestinal function

Intra-arterial method, 267

Intracellular fluid (ICF)
in adolescents, 195
in body fluids, 94, 96
in premature neonates, 192
in toddlers, 194

Intraoperative autotransfusion, 237

Intraosseous administration, 13

Intraosseous catheters, 80, 173, 208

Intraosseous needles, 81, 208

Intraspinal analgesia, 75–80

Intrathecal analgesia, 75–80

Intravascular fluids, 87

Intravascular hemolytic transfusion reactions, 245

Intravascular malposition, 67

Intravenous solutions. *See* Solutions

Intravenous therapy. *See* Infusion therapy

Intrinsic contamination, 167–168

Intropin (dopamine hydrochloride), 147–148

Iodine
nutritional requirements for, 180
tincture of, 181

Iodophors, 180

Iontophoresis, 212

Irinotecan, 282, 291

Iron
iron overload, 250
nutritional requirements for, 321–322

Irritants, 265

Isopropyl alcohol, 20, 180, 181, 189, 193

Isoproterenol hydrochloride, 148

Isoptin (verapamil hydrochloride), 150

Isotonic dehydration, 216–217

Isotonic solutions, 87, 119

Isuprel (isoproterenol hydrochloride), 148

IV push method, 267

J

Job descriptions, 360

Jugular veins, 6, 211

Junction securement devices, 70–71

K

Kernicterus, 207

Ketoacidosis, diabetic, 111, 128

Kidneys. *See* Renal function

Klebsiella
in catheter-related infections, 169–170, 172
in endogenous contamination, 168
in extrinsic contamination, 166
in intrinsic contamination, 167
lifespan/growth in solutions, 169
in septicemia/bacteremia, 188

Krebs cycle, 318

Kwashiorkor, 312–313

L

Labels, 179

Labetalol hydrochloride, 151

Laboratory testing. *See also specific laboratory tests*
in children, 205–207
in fluid and electrolyte assessment, 94–95
in nutritional assessment, 331–332
during parenteral nutrition, 350–351
for pharmacologic therapy, 133
prior to antineoplastic treatment, 263

Lactate salts, 336

Lactated Ringer's injection, 123–124

Laminar flow hood, 166

Lanoxin (digoxin), 149

Lasix (furosemide), 156

Laxatives, 89

Legal considerations
 of performance improvement, 363–369
 of pharmacologic therapy, 131–132
 Leucovorin calcium, 283
 Leukemia, 231
 Leukocyte-reduced platelets, 241
 Leukocyte-reduced red blood cells, 239
 Leukocyte-reduction filters, 254
 Leukocytes, 163
 Levophed (norepinephrine bitartrate), 148
 Liability, personal, 131, 365
 Libel, 364
 Lidocaine hydrochloride, 149–150, 212
 Ligaments, spinal, 10
 Ligamentum flavum, 10
 Linezolid, 141
 Linoleic acid, 318
 Lipids, 344. *See also* Fat
 Liquid medications, 134
 Liver failure, 326–327
 Liver function. *See* Hepatic system
 Lobes of brain, 8
 Local anesthetics, 212
 Locking, 27, 45
 Lorazepam, 270
 Luer slip connectors, 18
 Luer-Lock design, 20
 Lumbar nerves, 11
 Lumen of catheters, 26
 Lungs. *See* Respiratory function
 Lymphocytes, 164, 294

M

Macrobore (macrodrop) administration sets,
 17, 136
 Macrolides, 140
 Magnesium
 and cardiac function, 108, 128
 in children, 193
 hypermagnesemia, 110
 and hypocalcemia, 105–106
 hypomagnesemia, 108–110
 nutritional requirements for, 321
 overview of, 108–110
 and parenteral nutrition, 348
 in toxemia of pregnancy, 130
 Malnutrition, 312–313
 Malposition, catheter
 extravascular, 67
 intravascular, 67–68
 Malpractice, 363–364
 Manganese, 322
 Mannitol, 125, 157
 Marasmus, 313
 Marasmus-Kwashiorkor, 313
 Marcaine (bupivacaine hydrochloride),
 77, 146
 Maximal sterile barrier precautions, 175
 Maxipime (cefepime hydrochloride),
 138
 Mechanical complications, 49–50
 Mechanical infusion devices, 30
 Mechanical phlebitis, 54, 186
 Mechlorethamine hydrochloride, 283
 Median basilic vein, 6
 Median cephalic vein, 6
 Medical history
 arterial access, 73
 to assess fluid and electrolyte status, 89
 of children, 198–200
 of family, 200
 of medications, 132
 in nutritional assessment, 329
 of pediatric patients, 198
 prior to antineoplastic therapy, 261, 305
 prior to transfusions, 252–253
 Medical records
 of patient education, 54
 Medications. *See* Drugs
 Medulla oblongata, 9
 Mefoxin (cefoxitin sodium), 138
 Melanoma, malignant, 277
 Membrane filter, 22
 Meninges, 8, 11
 Meningitis, 225–226
 Mental status, 253
 Mesencephalon, 9
 Mesna, 283
 Mesnex (mesna), 283
 Metabolic acidosis, 91, 103–104, 115–116
 Metabolic alkalosis, 93, 116–117
 Metacarpal veins, 5
 Metatarsal veins, 210
 Methadone, 78
 Methotrexate, 283–284
 Methyldopate hydrochloride, 151
 Metoclopramide hydrochloride, 158, 270
 Metronidazole hydrochloride, 143
 Mexate-AQ (methotrexate), 283–284
 Microaggregate blood filters, 254
 Microbore (microdrip) administration sets,
 17, 76
 Midbrain, 9
 Midline catheters, 53, 208
 Milrinone lactate, 149
 Mitoxantrone hydrochloride, 284
 Mitral valve, 2
 Molybdenum, 322
 Monoclonal antibodies, 290–291
 Monocytes, 164

Mouth
 and fluid and electrolyte imbalance, 91
 and nutritional status, 330
 Mucositis, 271–272
 Mucous membranes, in children, 204
 Multi-entry extension sets, 19
 Multilumen catheters, 26
 Multivitamins, 160
 Mustargen (mechlorethamine hydrochloride), 283
 Mutamycin (mitomycin C), 284
 M.V.I. 12 (multivitamins), 160

N

Nausea, 270
 Navelbine (vinorelbine), 287
 Navigational and visualization devices, 27–28
 catheter location systems, 27–28
 light devices, 28
 ultrasound devices, 27
 Neck veins, 92
 Necrotizing enterocolitis, 229–230
 Needleless connectors (NCs), 19–20, 46
 Needleless systems, 183
 Needles, 23–24
 filter, 22, 183
 intraosseous, 208
 noncoring, 28
 stainless steel, 23, 74
 Negligence, 363–364
 Neonates. *See also* Children
 body surface area of, 194, 217
 pain management in, 212
 physiologic development of, 193–194
 psychosocial development of, 195–196
 Nephrotoxicity, 272
 Nerve conduction
 arterial, 2–3
 cardiac, 5–6
 and potassium, 103
 venous, 5
 Nerve injury, 58–59
 Nerves, 11–12
 Nervous system
 and antineoplastic therapy, 272
 autonomic system, 12
 brain in, 8–9
 peripheral system, 11–12
 spinal cord in, 9–11
 Neulasta (pegfilgrastim), 288
 Neumega (oprelvekin), 289
 Neupogen, 288
 Neuroblastoma, 232–233
 Neurologic examination
 in autoimmune disorders, 295
 in children, 205
 in fluid and electrolyte assessment, 92–93
 Neuromuscular activity
 and calcium, 93, 105
 and magnesium, 93, 105, 108, 110
 and metabolic alkalosis, 93
 and phosphate, 112–113
 and potassium, 104
 Neurotoxicity, 272
 Neutropenia, 269
 Neutrophils, 163–164
 Niacin, 324
 Nicardipine, 151
 Nipride (nitroprusside sodium), 152
 Nitrogen balance, 333
 Nitroglycerin, 152
 Nitroprusside sodium, 152
 Nonair-dependent containers, 14
 Noncoring needles, 25
 Nonessential amino acids, 315–316
 Nonvented administration sets, 16, 253
 Norepinephrine bitartrate, 148
 Normodyne (labetalol hydrochloride), 151
 Novantrone (mitoxantrone hydrochloride), 284
 Nursing history, 132–133. *See also* Medical history
 Nutrient balance, 312
 Nutrients, defined, 312
 Nutrition, parenteral. *See* Parenteral nutrition
 Nutritional assessment
 anthropometric measurements in, 331
 in children, 198–199
 definition of, 329
 dietary history in, 330
 fluid and electrolyte status in, 329
 glucose in, 332–333
 hemoglobin/hematocrit in, 333
 immunocompetence testing in, 332
 laboratory data in, 331–332
 medical history in, 329
 medication history in, 329
 nitrogen balance, 333
 physical assessment in, 330–331
 psychosocial assessment in, 330
 vital signs in, 329
 Nutritional deficiency, 312
 Nutritional requirements
 carbohydrates, 317–318
 determination of, 314
 for electrolytes, 319–321
 and energy requirements, 314–315
 for fat, 318–319
 for fluid, 319
 for protein, 315–317
 for trace elements, 321–322
 for vitamins, 323–325
 Nutritional status, 312

O

Obstetrics, epidural block in, 78
 Occipital lobe of the brain, 9
 Occipital vein, 7
 Occlusion, 56–57
 Occupational Safety and Health Administration (OSHA), 178, 268, 365
 Ocular toxicity, 273
 Ointments, antibiotic/antimicrobial, 181
 Oncovin (vincristine), 287
 Ondansetron hydrochloride, 158
 Open system containers, 14
 Opioids, 77, 212
 Opportunistic infections, 230
 Oprelvekin, 289
 Oral cavity, 91
 Organizations, regulatory, 365–366
 OSHA (Occupational Safety and Health Administration), 178, 268, 365
 Osmitol (mannitol), 157
 Osmolality
 serum, 94, 96, 99
 of solutions, 87
 urine, 95
 Osmolarity, 87
 Osmosis, 87
 Ototoxicity, 272
 Outcomes
 patient, 35–36
 performance standards for, 358
 Over-the-needle catheters, 24
 Oxaliplatin, 285–286
 Oxytocin, 159

P

Packed red blood cells (PRBCs), 238–240
 Paclitaxel, 284–285
 Pain management, in children, 211–212
 Palifermin, 289
 Pancreatitis, 326, 349
 Panitumumab, 291
 Pantothenic acid, 324
 Paraplatin (carboplatin), 275–276
 Parasympathetic innervation, 3, 5
 Parasympathetic nerves, 12
 Parathyroid gland, 88
 Parenteral nutrition
 administration equipment for, 345–346
 administration regimens, 351–354, 354
 for children, 311, 312
 central PN, 309, 311–312
 complications of, 346–350
 considerations for, 310

 cyclic regimens of, 342–343
 definition of, 309
 discontinuation of, 342
 documentation of, 351
 fluid changes with, 319, 350
 goals of, 309
 home parenteral nutrition, 351–354
 indications for, 310–312
 lipids, 344
 medication compatibility with, 345
 nutritional assessment for, 329–333
 patient monitoring during, 350–351
 peripheral (PPN), 309, 310–311, 339–340
 solutions, 190, 344
 albumin, 126, 242
 carbohydrate solutions, 334–335
 compatibility with medications, 344–345
 compounding, 341
 description of, 124
 dextran, 124–125, 157
 disease-specific formulas, 340–341
 electrolyte preparations, 336
 fat emulsions, 335–336
 formulas for, 339–340
 heparin, 338
 hetastarch, 125, 156–157
 histamine antagonists, 338
 insulin, 338
 mannitol, 125, 157
 medications and, 345
 multiple vitamin injection (MVI), 337
 preparation and storage of, 341
 protein solutions, 334
 rate of delivery, 342
 stability of, 344
 storage of, 341
 total nutrient admixtures, 338–339
 trace element preparations, 337
 vascular access for, 345
 Pareto charting, 361
 Parietal lobe of the brain, 8–9
 Parietal vein, 7
 Partial thromboplastin time (PTT), 133, 153–154
 Particulate matter filters, 23, 55
 Patient care plan, 132
 Patient education
 about parenteral nutrition, 353–354
 documentation of, 36
 evaluation of, 35–36
 implementation, 35
 learner assessment, 34–35
 overview of, 34
 teacher process, 35
 Patients
 age of, 73, 89–90, 132
 assessments of

- for antineoplastic therapy, 305
- fluid and electrolyte status, 89–95
- during infusions, 43–44
- nutritional, 329–333
- pain, 211–212
- for patient education, 35
- in pediatrics, 198–207
- for pharmacologic therapy, 132–133
- prior to infusion therapy, 34
- in site selection, 73
- for transfusions, 252–253
- disease status of, 89, 120, 132
- education of, 34–36
- identification of, 253
- informed consent of, 253, 367
- monitoring during parenteral nutrition, 350–351
- Pediatrics. *See* Children
- Pegfilgrastim, 288
- Pellagrous dermatosis, 330
- Pemetrexed, 285
- Penicillins, 137–138
- Pentam 300 (pentamidine isethionate), 144
- Pentamidine isethionate, 144
- Percent solutions, 137
- Periosteum, 13
- Peripheral arterial catheters, 185–186
- Peripheral catheters
 - for antineoplastic therapy, 266–267
 - complications of, 346
 - composition of, 23
 - contamination of, 172–174
 - dressing protocols for, 182–183
 - gauge and length of, 25
 - for pediatric use, 208
 - properties of, 23–24
 - removal of, 75
 - types of, 23
- Peripheral infusion therapy
 - site selection for, 37
 - veins appropriate for, 5, 37
- Peripheral nervous system, 11–12
- Peripheral parenteral nutrition (PPN).
 - See also* Parenteral nutrition
 - administration equipment for, 345–346
 - defined, 309
 - formulas for, 339
 - indications for, 310–312
 - venous access for, 345
- Peripheral site infection, 57
- Peripheral VADs, 23–25
 - indications for, 36
 - local anesthesia, 38
 - placement, 38–40
 - selection, 37–38
 - site preparation, 38
 - site selection, 36–37
- Peripherally inserted central catheter (PICC), 25,
 - 208–211, 345. *See also* Central vascular access devices
- Personal liability, 131, 365
- Personal protective equipment (PPE), 175–176
- Personnel, administering antineoplastic therapy,
 - 266
- Petechiae, 132, 330
- pH of solutions, 127, 135
- Pharmacology
 - for catheter-related infections, 191
 - in children, 213–215
 - drug administration, 134–137
 - calculations, 136–137
 - compatibility/stability, 135
 - containers, 135
 - forms, 134
 - methods of IV drug administration, 136
 - preparation, 134
 - stability, 135
 - drug classifications
 - alkylating agents, 273
 - anti-infective agents, 137–144
 - antimetabolites, 273
 - antitumor antibiotics, 273
 - biologic agents, 306–307
 - bone absorption inhibitors, 161
 - cardiovascular agents, 147–152
 - central nervous system agents, 144–147
 - electrolyte and water balance agents,
 - 155–157
 - gastrointestinal agents, 157–158
 - hematologic agents, 153–155
 - hormone and synthetic substitutes, 158–159
 - immune modulator agents, 159–160
 - irritants, 265
 - nitrosoureas, 273
 - respiratory smooth muscle relaxants, 160
 - vesicants, 265
 - vinca alkaloids, 273
 - vitamins, 160–161
 - investigational, 260–261
 - legal considerations for, 131–132
 - nursing process, 132–134
 - assessment, patient, 132–133
 - interventions, 133–134
 - laboratory data, 133
 - nursing responsibilities, 131
 - for pain management, 212
 - patient assessment for, 132–133
- Phlebitis, 54–56, 186–187
 - bacterial, 55, 186–187
 - causes of, 186
 - chemical, 54–55, 186
 - description of, 186
 - documentation of, 56

- Phlebitis (*continued*)
interventions for, 55–56
mechanical, 54, 186
and parenteral nutrition, 346
postinfusion, 55
prevention of, 56, 186–187
scale, 55f
thrombophlebitis, 346
- Phosphate
in children, 194, 205
hyperphosphatemia, 112–113
and hypocalcemia, 105
hypophosphatemia, 111–112
nutritional requirements for, 320
overview of, 111
and parenteral nutrition, 348
- Phosphorus. *See* Phosphate
- Phototherapy, 220
- Physical assessments
body weight, 92
cardiovascular system, 91–92
of children, 200–205
fluid intake and output, 90
neurological system, 92–93
in nutritional assessment, 330–331
parameters, 90
renal system, 90
senses, 91
skin appearance and temperature, 91
vital signs, 93–94
- Physical incompatibilities of drugs, 135
- Physiologic development
of adolescents, 195
of infants, 194
of neonates, 193–194
of premature neonates, 192–193
of preschoolers, 195
of school age children, 195
of toddlers, 194–195
- Phytonadione, 161, 324, 331
- Pia mater, 8, 11
- PICC. *See* Peripherally inserted central catheter
- Piggyback medications/solutions, 15, 16
- Pinch-off syndrome, 69
- Piston pumps, 29
- Pitocin (oxytocin), 159
- Pitting edema, 51, 96
- Pituitary gland, 88
- Plan of care, 266
- Plasma, fresh frozen, 240
- Platelets, 240–241, 254
- Platinol (cisplatin), 276
- Plexus, 11
- Pneumothorax, 64–65
- Policies and procedures
for investigational agents and protocols, 267
manuals for, 359
for performance improvement, 359–360
- Polymorphonuclear leukocytes, 163–164
- Pons, 9
- Positive pressure infusion pumps, 29
- Posterior longitudinal ligament, 11
- Postinfusion phlebitis, 55
- Postoperative blood salvage, 237
- Potassium
and cardiac function, 102, 104, 127
in children, 193
and chloride, 114
hyperkalemia, 103–105
hypokalemia, 101–103
nutritional requirements for, 320
overview of, 101
and parenteral nutrition, 347–348
and renal function, 101, 103, 128
- Potassium chloride/acetate, 103, 155
- Povidone-iodine, 180
- Powdered medications, 135
- PPN. *See* Peripheral parenteral nutrition
- Prealbumin, 332
- Pregnancy-induced hypertension, 129–130
- Premature neonates. *See also* Children
body surface area of, 192, 216
physiologic development of, 192–193
psychosocial development of, 195–196
- Premixed intravenous solutions, 127
- Premixed medications, 134
- Preschool children. *See also* Children
body surface area of, 195
pain management in, 212
physiologic development of, 195
psychosocial development of, 197
- Pressure cuff, blood administration, 255
- Pressure monitoring devices, 185–186
- Primary administration sets, 15
- Primacor (milrinone lactate), 149
- Primaxin (imipenem-cilastatin sodium), 139
- Procainamide hydrochloride, 149
- Procedures, preparation
for adolescents, 197–198
for infants, 196
for neonates, 195–196
for preschoolers, 197
for school age children, 197
for toddlers, 196
- Process standards, 358
- Proleukin (interleukin-2), 290
- Pronestyl (procainamide hydrochloride), 149
- Propranolol hydrochloride, 151
- Protamine sulfate, 153
- Protein
classification of, 315–316
compartments, 316

function of, 316
 metabolism of, 316
 in parenteral solutions, 334
 requirements for, 316–317
 retinol-binding protein, 332
 Prothrombin time (PT), 133
 Proton pump inhibitor, 157–158
Pseudomonas sp.
 in catheter-related infections, 170
 in endogenous contamination, 168
 in extrinsic contamination, 167
 in intrinsic contamination, 167
 Psychological assessments, 34
 Psychosocial issues
 of adolescents, 197–198
 of home parenteral nutrition, 352
 of infants, 196
 of neonates, 195–196
 in nutritional assessment, 330
 of parenteral nutrition, 352
 of preschoolers, 197
 of school age children, 197
 of toddlers, 196
 PT (prothrombin time), 133
 PTT (partial thromboplastin time), 133, 153–154
 Pulmonary arteries, 4, 74
 Pulmonary circulation, 3
 Pulmonary edema, 62–63
 Pulmonary embolism, 60
 Pulmonary function
 and antineoplastic therapy, 264, 272
 in cystic fibrosis, 224
 and nutritional status, 328
 Pulmonic semilunar valve, 2
 Pulse
 in children, 202
 in fluid and electrolyte balance, 93
 Pumps
 implanted, 32
 for pediatric use, 207
 piston, 28–29
 positive pressure infusion, 29
 syringe, 32, 207
 volumetric, 28
 Purkinje fibers, 3
 Pyloric stenosis, 221
 Pyridoxine hydrochloride, 160, 324
 Pyrogenic reactions, 188

Q

Quality, defined, 356
 Quality assurance (QA), 356
 Quality improvement (QI)
 corrective action, 362–363
 criteria for, 415
 data translation/interpretation, 362
 education, 358–359
 infusion related competencies, 369–370
 legal aspects and risk management, 363–369
 infusion-related competencies, 369–370
 negligence, 363–364
 organizational strategies, 366–369
 overview, 363
 professional organizations/associations, 366
 regulating agencies for, 365–366
 managing quality, 356–357
 organization/program design, 358–363
 overview of, 356–357
 policies, procedures and documents, 359–360
 standards for, 357–358
 structured model and process, 360–362
 torts, 364–365
 Quantitative cultures, 189
 Quinidine gluconate, 149
 Quinolone, 140
 Quinupristin/dalfopristin (Synercid), 141

R

Radial artery, 4, 74
 Ranitidine, 157
 Rapid flush technique, 67
 Rate of delivery
 drop factor in, 16–17
 of lipid solutions, 344
 of medications, 198
 and phlebitis, 54–55
 of PPN solutions, 342
 Recommended Dietary Allowance (RDA), 314
 Refeeding syndrome, 347
 Reglan (metoclopramide hydrochloride),
 158, 270
 Regulating agencies, 365–366
 Renal failure, 327, 340–341
 Renal function
 with antineoplastic therapy, 272
 in children, 193, 194, 194, 195
 in fluid and electrolyte balance, 97, 128
 homeostatic mechanisms of, 88
 and nutritional status, 327
 in potassium regulation, 102, 103
 Reports
 of contamination, 168
 drug-related malfunctions, 131, 365
 peripheral PN, 339
 risk management, 368
 of unusual occurrences, 54
 Reproductive function, altered, 273
 Resident flora, 172

Respiratory acidosis, 117–118
 Respiratory alkalosis, 118
 Respiratory distress syndrome, acute, 328
 Respiratory function
 and antineoplastic therapy, 263
 assessments of, 93
 in children, 202
 homeostatic mechanisms of, 88
 and hypocalcemia, 106
 and nutritional status, 328
 and parenteral nutrition, 350
 and phosphorus, 112
 Respiratory smooth muscle relaxants, 160
 Resting metabolic expenditure (RME), 314
 Retinol-binding protein, 332
 Retrograde administration sets, 15, 215
 Retrovir (zidovudine), 143
 Rh factor, 236
 in hemolytic disease of the newborn, 220
 typing for, 252
 Rh system, 236
 RhoGAM, 220
 Riboflavin, 324
 Rifadin (rifampin), 141
 Rifampin, 141
 Ringer's injection, 123–124
 5% dextrose in lactated Ringer's, 124
 5% dextrose in Ringer's injection, 123
 lactated Ringer's injection, 123–124
 Rituxan (rituximab), 291, 300
 Rituximab, 291, 300
 RME (resting metabolic expenditure), 314
 Rocephin (ceftriaxone sodium), 138
 Role-relationship pattern, in children, 199
 Roller clamps, 17
 Rule of Personal Liability, 365

S

SA (sinoatrial) node, 2
 Sacral nerves, 12
 Safflower oil emulsions, 335
 Salicylate intoxication, 223
 Salivation, 91, 204
 Sandimmune IV (cyclosporine), 159
 Sargramostim (leukine), 289
 Scalp veins, 7, 211
 School age children. *See also* Children
 body surface area of, 195
 pain management in, 212
 physiologic development of, 195
 psychosocial development of, 197
 SDA (specific dynamic action), 314
 Secondary administration sets, 45
 Securement devices, 70, 71

Sedatives, 145
 Seldinger technique, 42
 Selenium, 322
 Self-perception, in children, 199
 Semilunar valves, 2
 Semiquantitative cultures, 189
 Sensorium, assessment of, 92–93, 133
 Sentinel occurrences, 54
 Septicemia, 59–60, 188–189
 description of, 59, 188–189
 interventions for, 59
 preventive measures for, 60
 signs and symptoms of, 59
Serratia marcescens
 in catheter-related infections, 169–170
 in extrinsic contamination, 166–167
 in intrinsic contamination, 167
 Serum albumin, 331–332
 Serum glucose. *See also* Hyperglycemia;
 Hypoglycemia
 in children, 206
 in nutritional status, 95
 with parenteral nutrition, 348, 351, 353
 Serum osmolality
 in children, 206
 in fluid and electrolyte balance, 95
 in hyponatremia, 99
 Serum transferrin, 332
 Sexuality, altered, 273
 Shock
 and hypovolemia, 98
 speed, 63–64
 Short bowel syndrome, 325–326
 Short cap edema, 72
 SIADH (syndrome of inappropriate antidiuretic hormone), 99, 100, 128, 218
 Sickle cell anemia, 226–228
 Side effects. *See* Complications
 Single-lumen catheters, 26
 Sinoatrial (SA) node, 2
 Site, insertion
 bacterial contamination of, 172–174
 care and maintenance of, 43, 212–213
 complications of, 49, 346
 infection at, 172–174, 180, 187
 inspection of, 43, 184
 preparation of, 180–181
 selection of, 40–41, 210–211
 Site drainage cultures, 190
 Skeletal system, 12–13
 Skin
 appearance of, 91, 132
 capillary refill, 204
 of children, 193, 194, 199, 203–204
 color of, 203
 edema, 204

- fluid loss via, 89
- integumentary system, 8
- and nutritional status, 330
- petechiae on, 132, 330
- temperature of, 91, 203
- turgor of, 132, 204
- Slander, 364
- Slide clamps, 17
- Social needs
 - of adolescents, 197–198
 - of infants, 196
 - of neonates, 195–196
 - in nutritional assessment, 330
 - of preschoolers, 197
 - of toddlers, 196
- Sodium
 - and cardiac function, 127–128
 - in children, 194
 - and chloride, 113, 114
 - excess loss of, 99
 - hypernatremia, 100–101
 - and hypervolemia, 95–96
 - hyponatremia, 99–100
 - nutritional requirements for, 320
 - overview of, 98–101
 - and parenteral nutrition, 348
- Sodium bicarbonate, 104, 126, 156
- Sodium chloride solutions, 121, 126, 155
 - in blood administration, 253–254
- Sodium excess. *See* Hypernatremia
- Solaris, 290–291
- Solid caps, 20
- Solution containers
 - complications of, 49–50
 - cultures of, 190
 - frequency of change, 46
 - glass *vs.* plastic, 14
 - inspection before use, 46
 - nursing considerations for, 14
 - for pediatric use, 208
 - types of systems, 14
 - volume sizes, 14
- Solutions
 - albumin, 126, 242, 331–332
 - alkalinizing solutions, 126
 - antimicrobial, 181
 - bacterial contamination of, 169–170
 - carbohydrate, 334–335
 - compounding, 341
 - cultures of, 190
 - dextrose solutions, 334–335
 - dextrose/saline solutions, 169
 - disease-specific formulations, 340–341
 - electrolyte solutions, 123–124, 336
 - filters for, 21–23
 - heparin, 338
 - histamine antagonists, 338
 - inappropriate use of, 89
 - insulin, 338
 - lipid emulsions, 341
 - microorganism lifespan/multiplication in, 124
 - nonstandard, 340
 - for parenteral nutrition, 333–341
 - percent, 137
 - premixed solutions, 127
 - preparation of, 134, 353
 - protein, 334
 - sodium chloride solutions, 121, 155
 - storage of, 341
 - temperature of, 50
 - total nutrient admixture, 338–339
 - trace element preparations, 337
- Somatic compartment, 316
- Sorbitol, 317
- Soybean oil emulsions, 335
- Spasms, arterial or venous, 57–58
- Specific dynamic action (SDA), 314
- Specific gravity of urine, 95, 204
- Speed shock, 63–64
- Spike adapters, vented, 14, 50
- Spinal cord, 9–10
- Spinal ligaments, 10
- Spinal nerves, 11–12
- Spinous processes, 10
- Spring-coil containers, 32
- Spring-coil piston syringes, 32
- Stabilization devices, catheter, 21
- Stainless steel needles, 23–24
- Standard administration sets, 17
- Standard Precautions, 38, 74, 175–177
- Standards, performance
 - of care, 357–358
 - classification of, 358
 - of governance, 358
 - outcome, 358
 - overview of, 357
 - of practice, 358, 366
 - process, 358
 - structural, 358
 - types of, 358
- Staphylococcus* sp.
 - in catheter-related infections, 170, 171
 - in endogenous contamination, 169
 - in exogenous contamination, 168
 - in extrinsic contamination, 167
- Starvation, 313, 319
- State Board of Nursing, 366
- State Nurse Practice Act, 131, 366
- State regulatory boards, 365–366
- Steatorrhea, 327
- Stomach disorders. *See* Gastrointestinal function
- Stopcocks, 19

Storage
 of blood components, 254
 of solutions, 341
 Straight administration sets, 19, 255
 Straight extension sets, 19
 Streptozocin, 286
 Stress
 management of, in children, 199
 neonates response to, 195
 and nutritional status, 328
 and potassium loss, 102
 Subclavian vein, 6–7
 Subcutaneous tissue access
 advantages, 82
 care and maintenance, 83
 disadvantages, 82
 fluids intake, 82
 initiation, 82–83
 Sulfonamide combination, 144
 Superficial fascia (hypodermis), 8
 Superficial temporal vein, 7
 Superior vena cava (SVC) syndrome, 72
 Supraspinous ligament, 10
 Surgery, epidural block in, 78
 SVC (superior vena cava) syndrome, 72
 Sweat abnormality, 224
 Sympathetic innervation, 3, 5
 Sympathetic nerves, 12
 Sympathomimetic (adrenergic) agents, 147–148
 Syndrome of inappropriate antidiuretic hormone (SIADH), 99–100, 128, 218
 Syringe pumps, 28–29, 207, 214–215
 Syringes
 prefilled, 135
 preparation of, 134
 spring-coil piston, 32
 Systemic circulation, 3–7
 arteries in, 3–4
 blood flow in, 3–7
 capillaries in, 7
 veins in, 4–7

T

Tagamet (cimetidine hydrochloride), 157
 Tamponade, cardiac, 72–73
 Targeted therapies, 291–292
 Taxanes, 279
 Taxol (paclitaxel), 284–285
 Taxotere (docetaxel), 279
 TBW. *See* Total body water
 T-connectors, 19–20
 TDE (total daily energy), 314
 Teaching plans, 35
 Tearing, 91

Teeth, and nutritional status, 331
 Temperature
 of children, 201, 203
 of patient, 93, 132
 of skin, 92, 203
 of solutions, 50
 Temporal lobe of the brain, 9
 Temsirolimus, 292
 Termination of therapy
 assessment for, 119
 catheter removal, 46–48
 cyclic regimens, 396–397
 documentation of, 122–123
 infusion therapy, 46–48, 220
 Tetracaine, 77
 Tetracyclines, 139–140
 Therapeutic drug monitoring, 133
 Therapeutic incompatibilities of drugs, 135
 Thermometers, 201
 Thermoregulation system, of neonates, 193
 Thiamine hydrochloride, 161, 324
 Thioplex (thiotepa), 286
 Thiotepa, 286
 Thirst, 91, 128
 Thoracic nerves, 11
 Three-in-one solutions
 administration equipment for, 346
 bacterial contamination, 346
 Thrombate III (antithrombin III), 153
 Thrombocytopenia, 269
 Thrombophlebitis, 187, 346
 Through-the-needle catheters, 61
 Thyroid gland, 89, 128
 Tincture of iodine, 181
 Tissue turgor, 91, 132–133
 TNM staging system, 264
 Tobramycin sulfate, 139
 Toddlers. *See also* Children
 body surface area of, 194
 pain management in, 212
 physiologic development of, 194–195
 psychosocial development of, 196
 Tongue
 and nutritional status, 331
 turgor of, 91
 Tonicity of solutions
 defined, 87–88
 hypertonic solutions, 88
 hypotonic solutions, 88
 isotonic solutions, 87
 Topotecan, 286
 Torisel (temsirolimus), 292
 Torts, 364–365
 Total body water (TBW), 192, 194
 Total daily energy (TDE), 314
 Total nutrient admixtures, 338–339

- Total quality management (TQM), 357
 - Tourniquets, 39
 - Toxemia of pregnancy, 129
 - Toxicology screens, 133
 - TQM (total quality management), 357
 - Trace elements
 - deficiencies of, 348
 - nutritional requirements for, 321–322
 - parenteral preparations of, 337
 - Transdermal analgesic cream, 27
 - Transducers, 27, 74
 - Transferrin, 332
 - Transfusion reactions
 - allergic, 247
 - alloimmunization, 250
 - anaphylaxis, 247–248
 - bacterial contamination, 248–249
 - circulatory overload, 248
 - citrate toxicity, 249
 - cytomegalovirus, 251–252
 - febrile nonhemolytic, 246
 - hemolytic, 245–246
 - hepatitis, 251
 - human T-cell lymphotropic virus, 251
 - hypothermia, 249
 - iron overload, 250
 - opportunistic infections, 251
 - potassium toxicity, 249
 - TA-GVHD, 251
 - transfusion-associated circulatory overload (TACO), 248
 - transfusion-related acute lung injury (TRALI), 246–247
 - transfusion-related immunomodulation (TRIM), 252
 - Transfusions
 - administration, 253–256
 - administration pressure cuff for, 255
 - adverse reactions to, 245–252
 - albumin, 242
 - autologous, 237
 - blood warmers for, 254–255
 - of cryoprecipitate, 241–242
 - documentation of, 255–256
 - equipment for, 254–255
 - exchange, 220
 - of Factor VIII concentrate, 243
 - of Factor IX concentrate, 243
 - of fresh frozen plasma, 240
 - granulocytes, 244–245
 - intraoperative autotransfusion, 237
 - isovolemic hemodilution, 237
 - of packed red blood cells, 238–240
 - patient assessment for, 252–253
 - plasma protein fraction, 242–243
 - of platelets, 240–241
 - postoperative blood salvage, 237
 - preadministration of, 253
 - Rh immune globulin, 244
 - of whole blood, 237–238
 - Transient flora, 172
 - Transmission-based precautions, 177–178
 - Transparent semipermeable membrane (TSM), 44
 - changing, 44
 - protocols for, 182–183
 - Trastuzumab, 291
 - Trauma
 - and fluid and electrolyte balance, 129, 319
 - and nutritional status, 328–329
 - Treanda, 275
 - Tricuspid valve, 2
 - Tridil (nitroglycerin), 152
 - Trisonox (arsenic trioxide), 274
 - Trousseau's sign, 93
 - TSM. *See* Transparent semipermeable membrane
 - Tumor burden, 259
 - Tumors
 - neuroblastoma, 232–233
 - Wilms', 231–232
 - Tunica adventitia, 3, 5
 - Tunica intima, 3, 4
 - Tunica media, 3, 4–5
 - Tunneled catheters, 25, 77
 - insertion of, 26
 - Turgor
 - of skin, 91, 132–133, 204
 - of tongue, 91
 - Twiddler's syndrome, 69–70
- ## U
- Ulcerative colitis, 326
 - Ulnar artery, 4, 74
 - Umbilical arterial catheter (UAC), 209
 - Umbilical arteries, 211
 - Umbilical catheters, 174, 208–209
 - Umbilical vein, 7, 211
 - Umbilical venous catheter (UVC), 208–209
 - Unipen (nafcillin sodium), 137
 - Universal administration sets, 16
 - Unusual occurrence reports
 - of extravasation, 54
 - of infiltration, 74
 - Urine
 - concentration of, 90
 - drug testing of, 133
 - glucose in, 206
 - osmolality of, 95
 - output of, 204
 - specific gravity of, 95, 99
 - volume of, 90

V

- VAD (vascular access device). *See* Catheters
- Vaccines, 291
- Valium (diazepam), 145
- Valves, cardiac, 2
- Vancocin (vancomycin hydrochloride), 141–142
- Vancomycin hydrochloride, 141–142
- Vascular access
- for antineoplastic therapy, 266–267
 - arteries appropriate for, 4
 - in children, 210–211
 - for parenteral nutrition, 345, 352
- Vascular access devices (VAD). *See* Catheters
- Vascular system
- cardiac circulation, 1–3
 - pulmonary circulation, 3
 - systemic circulation, 3–7
- Vasodilator agents, 152
- Vectibx (panitumumab), 291
- Veins
- of antecubital fossa, 210
 - for antineoplastic therapy, 345
 - basilic, 5, 6, 210
 - brachial, 6, 210
 - for central intravenous therapy, 6–7
 - cephalic, 5, 6, 210
 - characteristics of, 5
 - in children, 211
 - digital, 5, 210
 - dilation techniques, 39
 - femoral, 7
 - foot, 210
 - forearm, 210
 - frontal, 7
 - greater saphenous, 7, 210
 - hand, 210
 - jugular, 6, 211
 - layers of, 4–5
 - locating with ultrasound, 27
 - median antebrachial, 5
 - metacarpal, 5
 - neck, 73, 96
 - nerve conduction in, 5
 - occipital, 7
 - parietal, 7
 - for peripheral infusion therapy, 5–6
 - scalp, 7, 211
 - in site selection, 36–37
 - subclavian, 6–7
 - superficial temporal, 7
 - umbilical, 7, 211
- Velban (vinblastine), 287
- Velcade (Bortezomib), 292
- Venipuncture
- in children, 210–213
 - for insertion of catheters, 63
 - pain management for, 211–212
 - site selection for, 210–211
 - techniques for, 39, 212–213
- Venous spasm, 57–58
- Venous thrombosis, 69
- Vented administration sets, 14, 50
- Vented spike adapters, 14, 50
- Ventricles
- of brain, 9
 - of heart, 2–3
- Ventricular reservoir, 75–80
- VePesid (etoposide), 280
- Verapamil hydrochloride, 150
- Vertebral column, 10
- Vesicants
- agents, 265
 - and extravasation, 51–53
- Vials, 135, 176–177
- Vibramycin IV (doxycycline hyclate), 139
- Vidaza (azacytidine), 274–275
- Vinblastine, 287
- Vinca alkaloids, 259, 273
- Vincristine, 287
- Vinorelbine, 287
- Visceral compartment, 316
- Visual disturbances, 227
- Vital signs
- in fluid and electrolyte balance, 93–94
 - in nutritional status, 329
 - during parenteral nutrition, 350
 - prior to infusion therapy, 93–94
- Vitamins, 160–161, 323–325
- biotin, 324–325
 - classifications of, 323
 - deficiencies of, 349
 - definition of, 323
 - factors that alter status of, 323
 - folic acid, 160, 325
 - multivitamins, 160
 - niacin, 324
 - pantothenic acid, 324
 - parenteral preparation, 336
 - properties/requirements of, 323
 - pyridoxine, 160, 324
 - riboflavin, 324
 - thiamine, 161, 324
 - vitamin A, 323
 - vitamin B₁₂ (cyanocobalamin), 325
 - vitamin C (ascorbic acid), 325
 - vitamin D, 323
 - vitamin E, 323
 - vitamin K₁ (phytonadione), 161, 324, 337

Volumetric pumps, 28
Vomiting, 198, 270
Von Willebrand's disease, 241, 243
VP-16 (etoposide), 280

W

Warmers, blood and fluid, 254–255
Water, intake and loss of, 99, 100
Water balance agents, 155–157
Weight, body
 of children, 200
 and fluid status, 86, 92
 gain and loss of, 92
 and nutritional status, 331
 during parenteral nutrition, 350, 353
 and pharmacologic therapy, 132
 recording, 92
White blood cells, 163
White matter, 8, 10
Whole blood, 237–238
Wilm's tumor, 231–232

X

Xylitol, 317
Xylocaine hydrochloride for cardiac arrhythmia
 (lidocaine hydrochloride), 149–150

Y

Y-connectors, 19
Y-type administration sets, 15, 255
Y-type extension sets, 19, 255

Z

Zanosar (streptozocin), 286
Zantac (ranitidine), 157
Zidovudine, 143
Zinc, 321–322
Zofran (ondansetron hydrochloride), 158
Zovirax (acyclovir sodium), 143
Zyvox (linezolid), 141