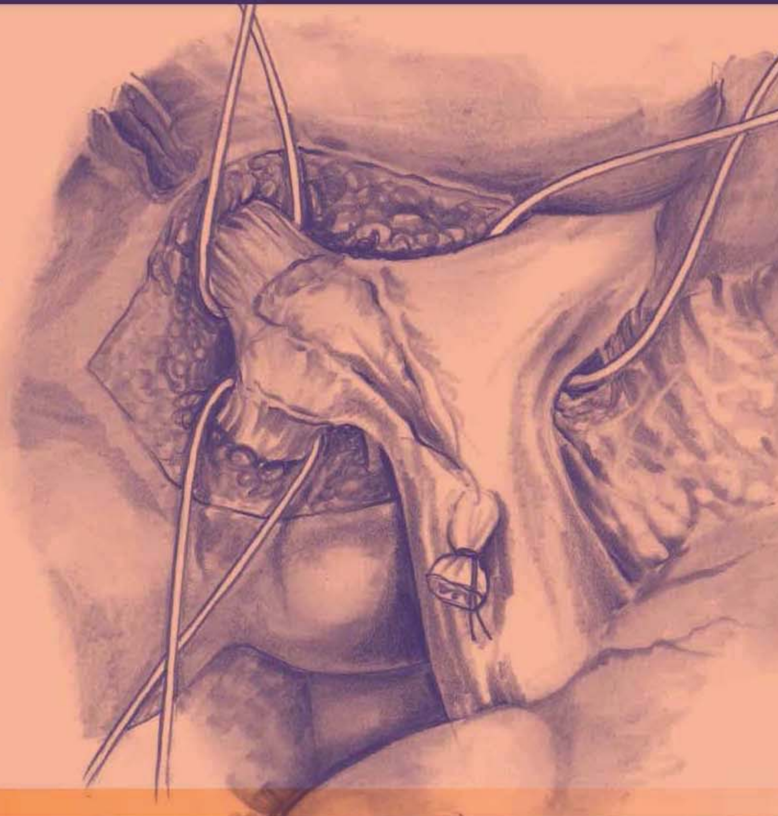
Ken Takasaki



Glissonean Pedicle Transection Method for Hepatic Resection

DVD-VIDEO INCLUDED

Springer

Ken Takasaki

Glissonean Pedicle Transection Method for Hepatic Resection

Ken Takasaki

Glissonean Pedicle Transection Method for Hepatic Resection

With 238 Illustrations, Including 59 in Color

Springer

Ken Takasaki, M.D.
Professor Emeritus
Institute of Gastroenterology
Tokyo Women's Medical University;
Rissho Koseikai Kosei Hospital
5-25-15 Yayoi-cho, Nakano-ku
Tokyo 164-8617, Japan

Medical Illustration: Leon Sakuma

Library of Congress Control Number: 2006938394

ISBN 978-4-431-48943-6 Springer Tokyo Berlin Heidelberg New York

Springer is a part of Springer Science+Business Media
springer.com

Printed in Japan

Typesetting: SNP Best-set Typesetter Ltd., Hong Kong
Printing and binding: Hicom, Japan

Printed on acid-free paper

Foreword

The first time I met Professor Takasaki was in 1986, at the CICD meeting in Jerusalem, when he presented his personal technique for liver resection. I was very enthusiastic about the originality and simplicity of his method and suggested that he report his experience. I told him that if he wrote a book, I would write the foreword for it. Here I keep my word.

Professor Takasaki's technique for liver resection derives from an original concept of anatomical division of the liver into three segments based on the distribution of the portal branches. This might seem strange when we have been used to the Couinaud anatomy for the past 20 years. In fact, however, there is a close correlation between the two anatomies if we consider that the right portal branch is short or even nonexistent. We can say that portal blood is distributed to three portions of the liver: the right segment, the middle segment, and the left segment for Takasaki; and the right posterior sector, the right anterior sector, and the left liver for Couinaud.[1] Thus the liver is divided into three in both classifications.

The second original contribution by Professor Takasaki is the approach to the portal pedicles inside the liver parenchyma. Initially, I was opening the Glisson capsule to clamp and ligate the vascular elements independently but changed many years ago to the Takasaki technique, which is easier, quicker, and safer. Apart from the Pringle maneuver for the whole liver, this technique is the best way to control a part of the liver for liver resection in a real anatomical manner. The video material that accompanies this volume shows the most common liver resections carried out using this technique and provides the best illustration of its quality.

[1] The similarity is even greater if we consider, as I said in 1982 in "Anatomical surgery and surgical anatomy of the liver" (World J Surg 6:3–9), that segments 4 and 3 of Couinaud are indeed artificially separated by the exteriorization of the left portal vein by the round ligament: segments 4 and 3 are one segment and, with segment 2, represent one sector. The left liver is indeed one sector. Therefore, the liver is three segments for Takasaki and three sectors (each divided into two segments) for me.

Professor Takasaki is to be complimented for the pioneering advances he has made in the history of liver surgery.

HENRI BISMUTH
Member of the French Academy of Surgery
Honorary Fellow of the American College of Surgeons
Honorary Fellow of the American Surgical Association

Foreword

In the field of liver surgery, metastatic liver tumors and primary liver cancer are the two major diseases to be treated. Among the latter, hepatocellular carcinoma is the most prominent and frequent disease encountered in Asia. Surgical treatment for hepatocellular carcinoma is more challenging than for metastatic tumors because of the underlining fibrosis and cirrhosis due to viral hepatitis. Pursuit of the optimal balance between the radical step of removal of the cancer and preservation of the noncancerous liver parenchyma becomes a matter of significance.

The surgical technique for hepatocellular carcinoma (HCC) is demanding. For example, due to liver cirrhosis, hemostasis after liver transection is much more difficult than that for metastatic tumors. Many new techniques have been developed in Asian countries, where hepatocellular carcinoma is prevalent and many hepatic surgeons have been fighting this dismal disease: Tien-Yu Lin from Taiwan, GB Ong from Hong Kong, M Balasegaram from Malaysia, Ton-That Tung and Trinh Van Minh from Vietnam, Ichio Honjo and others from Japan.

Professor Takasaki was with Tokyo Women's Medical University, School of Medicine, for 36 years. During his long career, he devised many new techniques and methodologies that are now considered essential to liver surgery. Among his major contributions are the remaining liver function test, the portal pedicle dissection method from the hilum, and the "anterior approach" in hemi-liver resection.

The remaining liver function test was developed to predict the postoperative hepatic failure from the retention rate of indocyanine green at 15 minutes (ICG 15′) and the remnant liver volume. When the postoperative ICG 15′ value exceeds 40%, the patient is likely to suffer from liver dysfunction. The "anterior approach" for extended right hemihepatectomy is a technique in which the liver parenchyma is transected from the anterior surface of segment 4 to the inferior vena cava. The technique can be found first in a figure in T. Starzl's paper, published in 1980 in *Surgery, Gynecology & Obstetrics*. The title of the paper was, however, "Right Trisegmentectomy for Hepatic Neoplasms," and the details of the technique were not well described. The technique was described in detail as the "anterior approach" for the first time by Edward C.S. Lai from Hong Kong in 1996, in the journal *World Journal of Surgery*. However, Professor Takasaki introduced a detailed, precise description of the technique at an international meeting held in Padua in 1992, 4 years earlier than the Hong Kong group's report. Unfortunately, his work failed to gain international recognition, because the publication of the technique was limited to a Japanese-language surgical journal at the time. Similarly, Professor Bernard Launois from France is often incorrectly thought to have been the first to introduce the method of portal pedicle dissection from the hepatic hilum in the literature. Professor Launois described it as the "posterior" intrahepatic approach in 1992.[1] One must realize, however, that Professor Takasaki had described the innovative and elegant technique in 1986, that is, 6 years earlier, long before the publication by Professor Launois. The portal pedicle dissection from the hepatic hilum, or the "Glissonean pedicle transaction method" for hepatic resection, is Professor Takasaki's invention.

When a small unit of the liver is resected, it should be strictly anatomical in patients with HCC. Identification of the relevant area of the liver is essential for this purpose. We performed dye injection into the portal venous branch while Professor Takasaki dissected and clamped the portal pedicles from the hepatic hilum for this purpose.

I am devoted to Professor Takasaki because he is a true liver surgeon, a man of few words, with a sharp mind and excellent hands. He has fought furiously against a deadly disease, and has never ceased his criticism of others, or of himself, to achieve true improvement in the field. He has performed almost 4000 hepatectomies at Tokyo Women's Medical University, School of Medicine.

This volume contains the essence of his ideas and clinical experiences in liver surgery. Its publication is definitely a milestone, and offers a great wealth of experience to both new and experienced surgeons alike who genuinely wish to become masters of liver surgery. The book is filled with original concepts in liver surgery for hepatocellular carcinoma, concepts that are essential for today's HPB surgeons.

Masatoshi Makuuchi
Professor, Surgeon in Chief
Hepato Biliary Pancreatic Surgery Division
Artificial Organ and Transplantation Division
Department of Surgery, Graduate School of Medicine,
University of Tokyo
and
Chairman, Department of Surgery
University of Tokyo Hospital

[1] The importance of Glisson's capsule and its sheaths in the intrahepatic approach to resection of the liver. Surgery, Gynecology & Obstetrics, 1992, 174(1):7–10

Preface

In liver surgical procedures, the blood flow supplying the area to be resected must first be stopped to minimize blood loss. It is commonly recognized that hepatocellular carcinoma metastasizes through the portal vein, spreading into the liver and causing intrahepatic metastasis in the area of the liver nourished by the cancer-bearing portal branch. Therefore, the area nourished by the cancer-bearing portal branch should be totally resected in a systematic manner. In order to prevent intrahepatic dissemination of carcinoma during surgery, it is important that, prior to manipulation of the liver, the cancer-bearing branch be ligated.

Since 1950, the standard procedure for hepatic surgery in the West has been the so-called controlled method. That is, the hepatic artery, portal vein, and bile duct are separately ligated and cut at the hepatic hilum for right or left hepatic resection. In the West, hepatic resection has been done mostly for metastatic liver cancer, and the term simply refers to lobectomy.

Applying the techniques of lung surgery to hepatic surgery, Dr. T.Y. Lin devised and reported in 1958 a new procedure named the "finger fracture method" in which the parenchyma of the liver is fractured bluntly with the fingers and the strands not "fractured" are ligated and cut.

In the history of hepatic surgery, these two procedures have been compared and discussed. However, the basic principle of each is different, so it is not necessary to choose between the two. In a systematically precise liver resection, even if a small area is resected, the portal triad should be treated (or manipulated) as proximally as possible. For this purpose, neither of the two methods is indicated; therefore, a new technique needed to be devised.

When I began to study liver surgery, I learned a great deal in the liver cancer treatment study group that was conducted by Dr. Hiroshi Hasegawa, Dr. Susumu Yamazaki, Dr. Masatoshi Makuuchi, and others. Dr. Makuuchi (now a professor at Tokyo University) established the systematic resection of the liver by making full use of sonography. After that, I developed the same kind of systematic liver resection by another approach.

It is possible that at the hepatic hilum, each artery, portal vein, and bile duct of the primary and secondary branches of the portal triad can be ligated and cut separately. However, in the more peripheral area, inside the liver parenchyma, the artery, portal vein, and bile ducts exist as one bundle covered by connective tissues, i.e., Glisson's sheath. Therefore, so far I have been compelled to manipulate the portal triad as one bundle.

For that reason, I devised a new method in which I treated vessels of the portal triad, always taking the Glissonean pedicle into consideration.

Whether it is a segmentectomy or a lobectomy or even a small resection of the liver, the portal triad can be cut either in the intrahepatic portion or the hepatic hilum, followed by dissection of the parenchyma. I originated this procedure in 1984, and since then I have performed more than 2000 hepatic resections for hepatocellular carcinoma with it. The figure below shows the number of hepatic resections performed for hepatocellular carcinoma. All of these resections have been completed without problems.

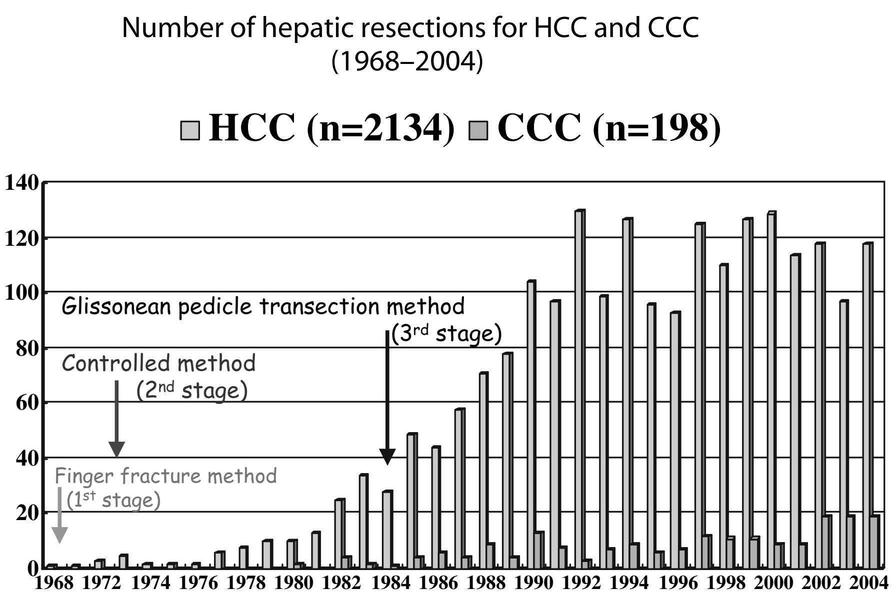
The clinical experiences reported in this volume were completed with the support of many leaders in the field, among whom I would name Prof. Komei Nakayama (our major leader), Prof. Seiichiro Kobayashi, Prof. Fujio Hanyu, Prof. Mitsuo Endo, Prof. Yukio Mikoshiba, Prof. Michio Iwatuka, and Prof. Kyoichi Hamano, in addition to many other colleagues.

I thank Mr. Leon Sakuma, my favorite artist, for his illustrations. Photography and editing of the attached DVD were done by Mr. Akira Miyama, Mr. Kazuhiro Muraoka, Mr. Yutaka Suzuki, and the staff of the Imaging Information Research Center, Photography Division, of Tokyo Women's Medical University.

I am also grateful to my friends Dr. Akira Fujimoto, Dr. Kuranosuke Miyauchi, and Prof. David Baldwin for their encouragement and support.

When I started writing this book, my aim was to create a textbook of hepatic resection; but now, after completing the editing of the contents, I believe that it has become a history of hepatic surgery. I look forward to further developments by young surgeons in the field.

Revised 30 Nov 06



Contents

1 Glissonean Pedicle Tree

Components of the Glissonean Pedicle

The Glissonean pedicle consists of three kinds of vessels: portal vein, portal artery, and bile duct.

Glisson's capsule (Fig. 1.1), on the surface of the liver, extends into the liver and covers the portal triads, where it is called Glisson's sheath. Glisson's

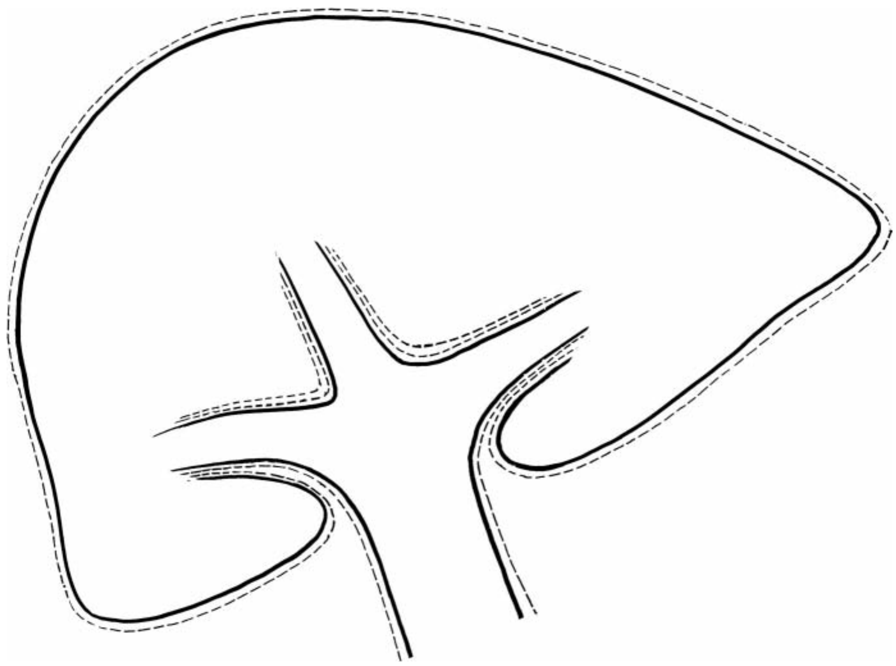
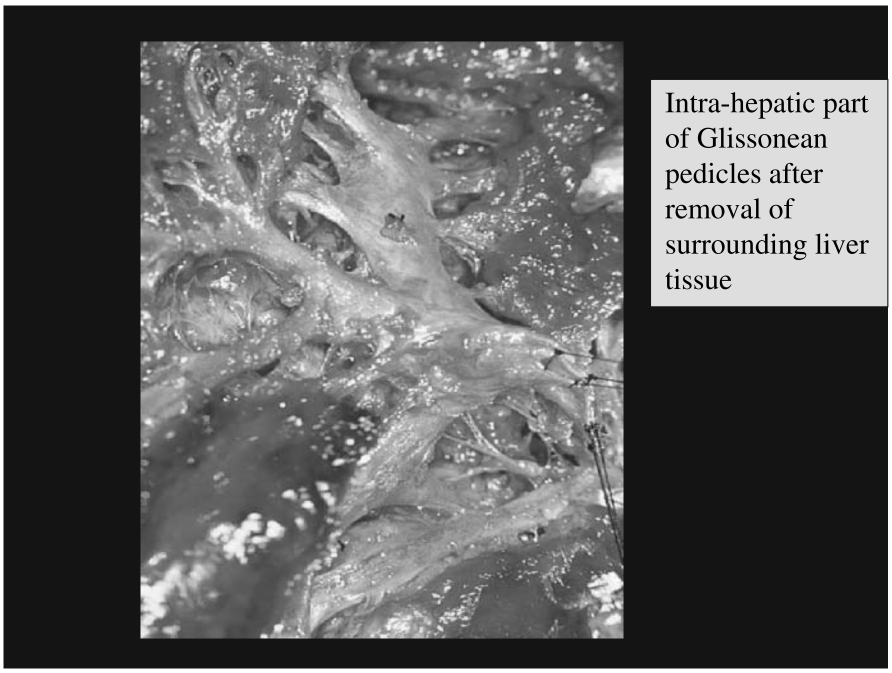


Fig. 1.1. Glisson's capsule, shown by the *dotted lines*

capsule also covers the Glissonean pedicles inside the liver. Therefore, the term "Glisson's sheath" is generally used only to refer to the portion of the Glissonean pedicle inside the liver. Figure 1.2a,b shows the components of the Glissonean pedicle.

In the extrahepatic portion of the Glissonean pedicle, the portal triads in the hepatoduodenal ligament are also enclosed by connective tissue and peritoneum up to the hepatic hilum. The intrahepatic and extrahepatic portions of the portal triads have the same structure anatomically. In other words, the extrahepatic and intrahepatic portal triads can be considered as parts of the same Glissonean pedicle tree.



a

Fig. 1.2a. The Glissonean pedicle tree, intraoperative photograph. After removing the surrounding liver tissue, care is taken not to damage the vessels, using a Cavitron ultrasonic aspirator (CUSA) on the resected specimen of the right lobectomy. Not visible are arteries, veins, and the bile duct; seen here is the fibroid bundle called the Glissonean pedicle. It consists of two main trunks and several branches of almost the same length, which are bifurcated from the main trunk. The structure is connected to the outside of the liver and hepatoduodenal ligament. This fibroid bundle system is called the Glissonean pedicle tree

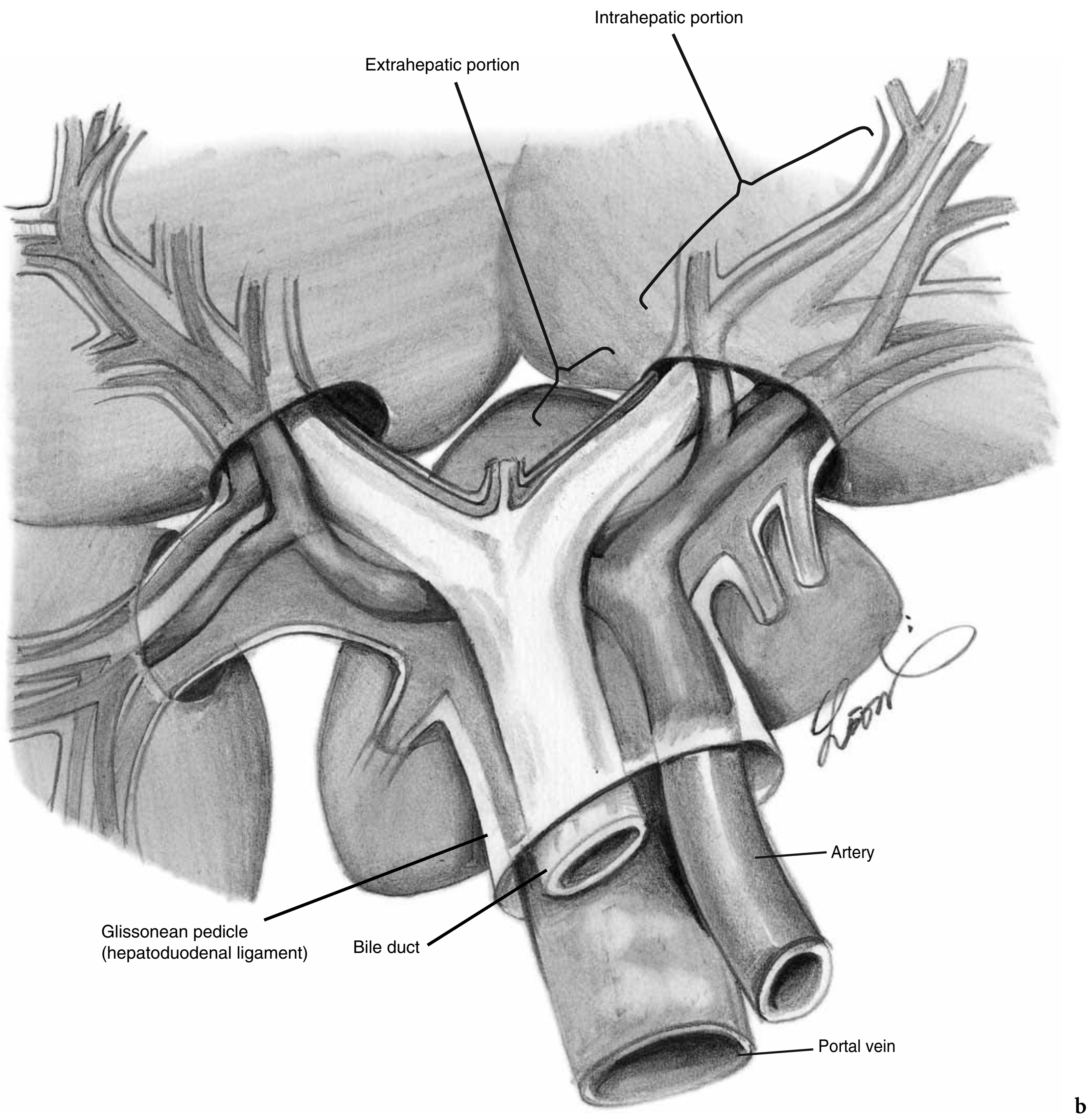


Fig. 1.2b. Components of the Glissonean pedicle

Branching Pattern of the Glissonean Pedicle Tree

Figure 1.3 shows the Glissonean pedicle tree. The hepatoduodenal ligament forms the main trunk of the Glissonean pedicle tree, which expands into two branches, the right and left primary branches, at the hepatic hilum. The right branch subdivides into two secondary branches. The left branch proceeds to a transverse portion and then continues to the umbilical portion (i.e., the secondary branch; Fig. 1.3). Blood is supplied to the liver by the three secondary branches of the Glissonean pedicle tree. Both of the primary branches are located outside the liver, while the secondary and more peripheral branches run inside the liver.

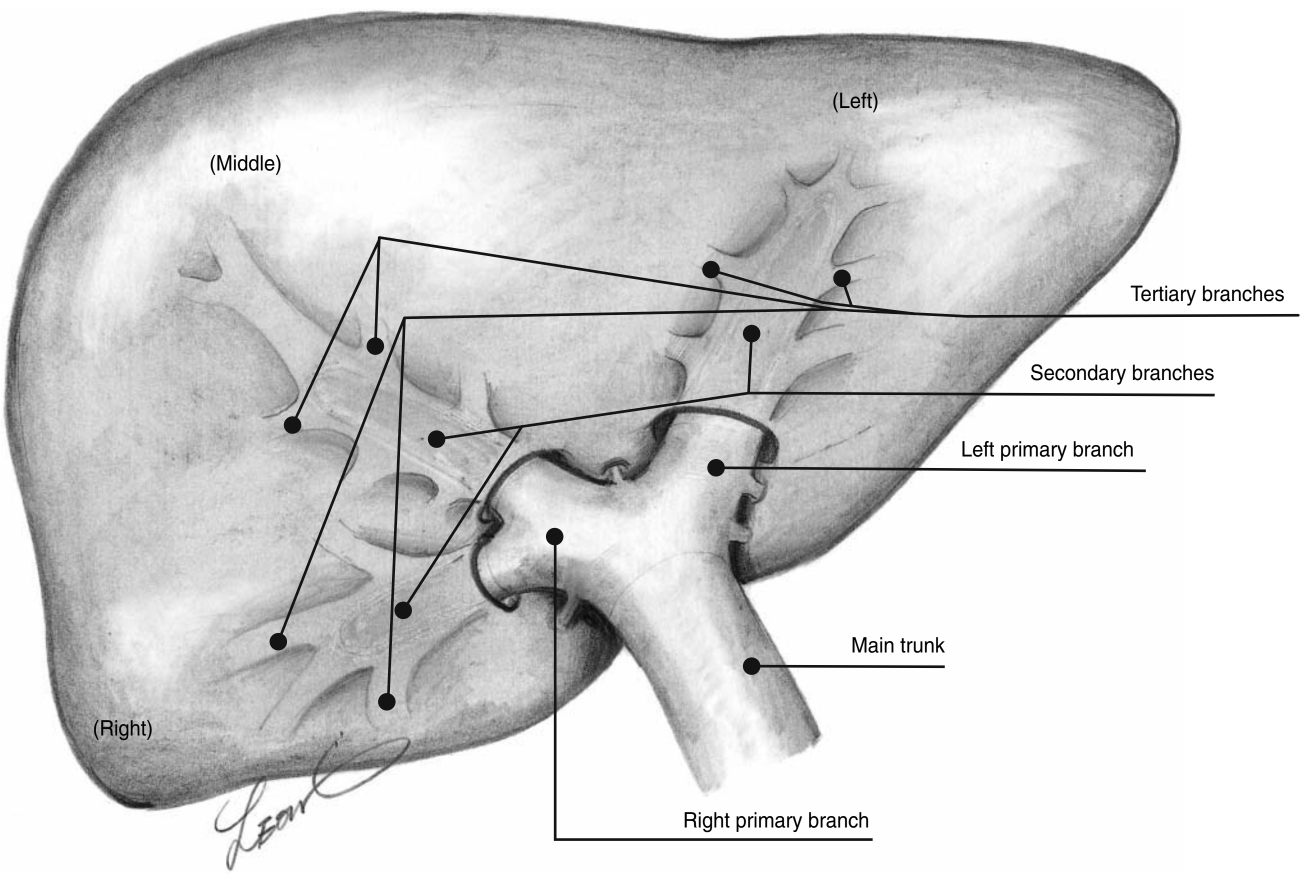


Fig. 1.3. Glissonean pedicle tree

Advance of the Secondary Glissonean Pedicle Tree Branches into the Liver

Figure 1.4 shows the entry of the branches of the Glissonean pedicles into the liver at the hepatic hilum. Three secondary branches—that is, those contributing to the right, middle, and left segments—enter the liver through separate openings, while some small branches go to the caudate area, entering the liver through smaller openings. All of these openings begin at the hepatic hilum and lead to the liver parenchyma.

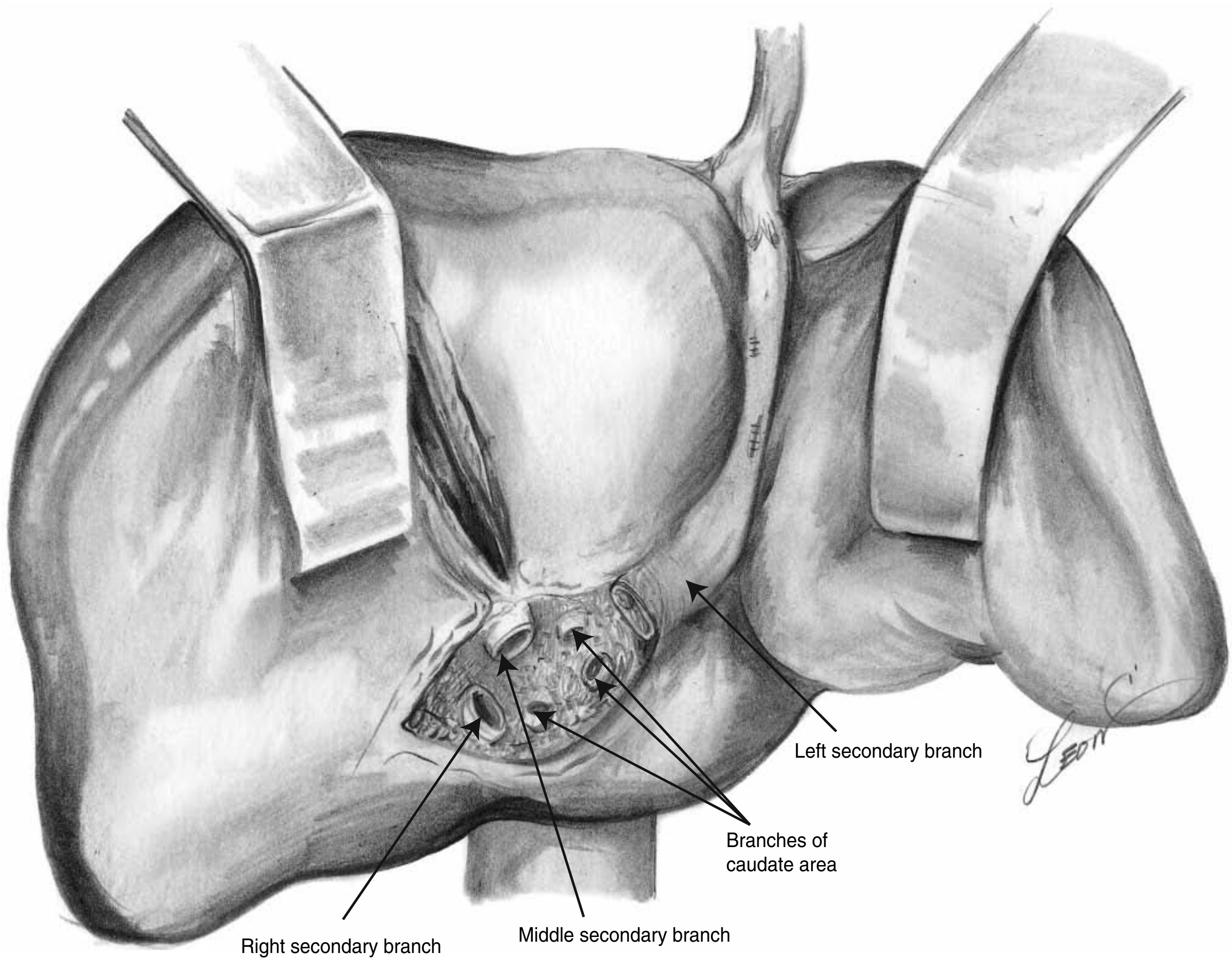


Fig. 1.4. Entry of the Glissonean pedicles into the liver at the hepatic hilum

2 New Concept of Liver Segmentation on the Basis of the Glissonean Pedicle (Takasaki's Segmentation)

Three Segments and One Caudate Area (Fig. 2.1)

The blood supply of the liver is derived from the three secondary branches of the Glissonean pedicle, and each secondary branch feeds one segment. Consequently, the liver can be separated into three segments: right, middle, and left. There is one additional area, called the caudate area, which is nourished directly from the primary branch. The three segments are almost the same size, each accounting for about 30% of the total liver volume, with the remaining 10% occupied by the caudate area.

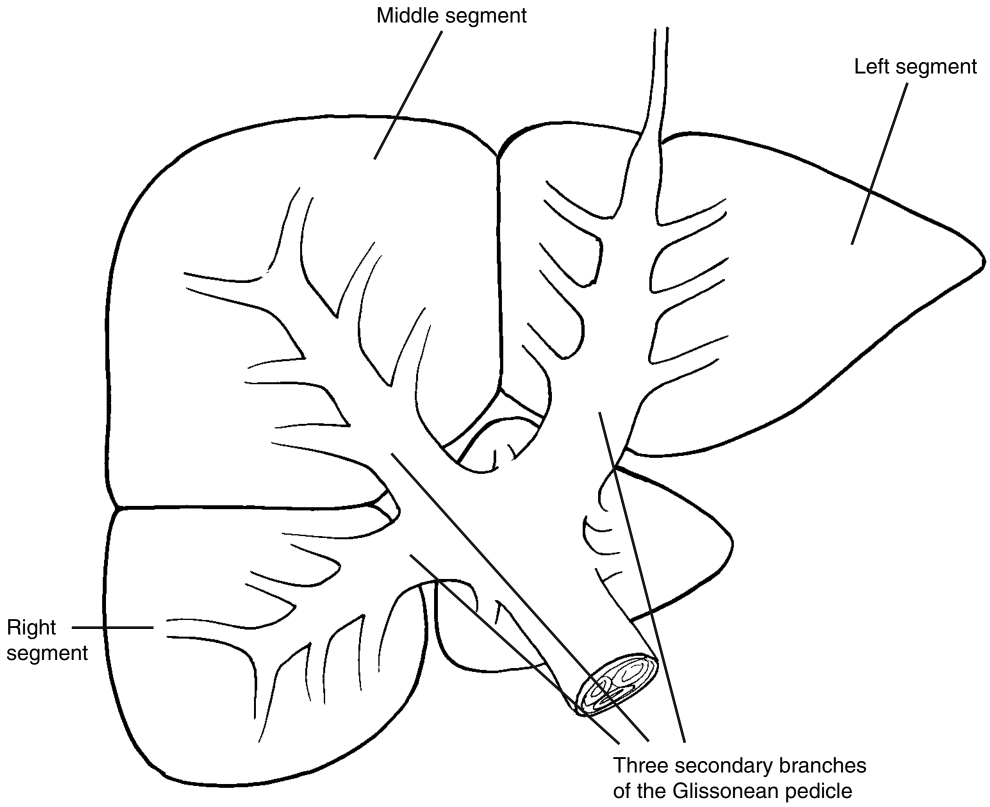


Fig. 2.1. Takasaki's segmentation

Relationship Between the Hepatic Veins and the Three Segments (Fig. 2.2)

Generally speaking, the hepatic vein is comprised of three veins: right, middle, and left. The right hepatic vein runs between the right segment and the middle segment, that is to say, the intersegmental plane. The middle hepatic vein runs between the middle segment and the left segment.

In many individuals, the middle and left hepatic veins meet each other and form a common channel, draining into the inferior vena cava (IVC). Therefore, the left hepatic vein is regarded as a branch of the middle hepatic vein. The left hepatic vein drains only the left segment. Thus, it is a general rule that the two main hepatic veins, right and middle, run along the intersegmental plane. Also, several short hepatic veins come from the caudate area that surrounds the inferior vena cava (IVC) and flow directly into the IVC.

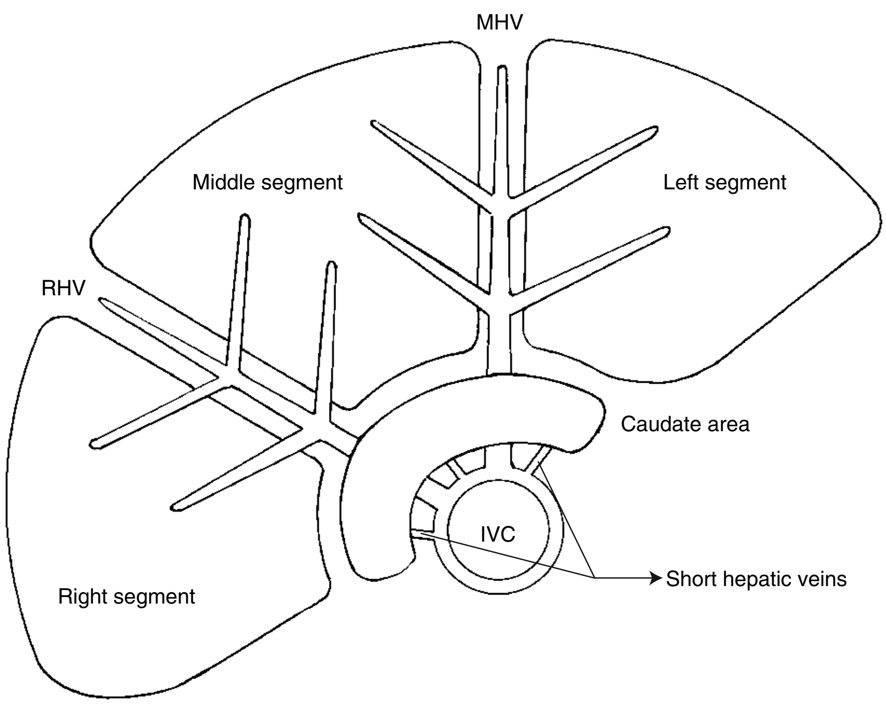


Fig. 2.2. Relationship between the hepatic veins and the three segments. *IVC*, inferior vena cava; *RHV*, right hepatic vein; *MHV*, middle hepatic vein

Relation Between Liver Segments and Vessels (Fig. 2.3)

Each segmental branch feeds its corresponding segment. The main hepatic vein consists of two main branches, right and middle. Each hepatic vein is located on the respective intersegmental plane between the right and middle segments and the left and middle segments.

The right hepatic vein acts as a draining vein for the right and middle segments, while the middle hepatic vein acts as a draining vein for the left and middle segments.

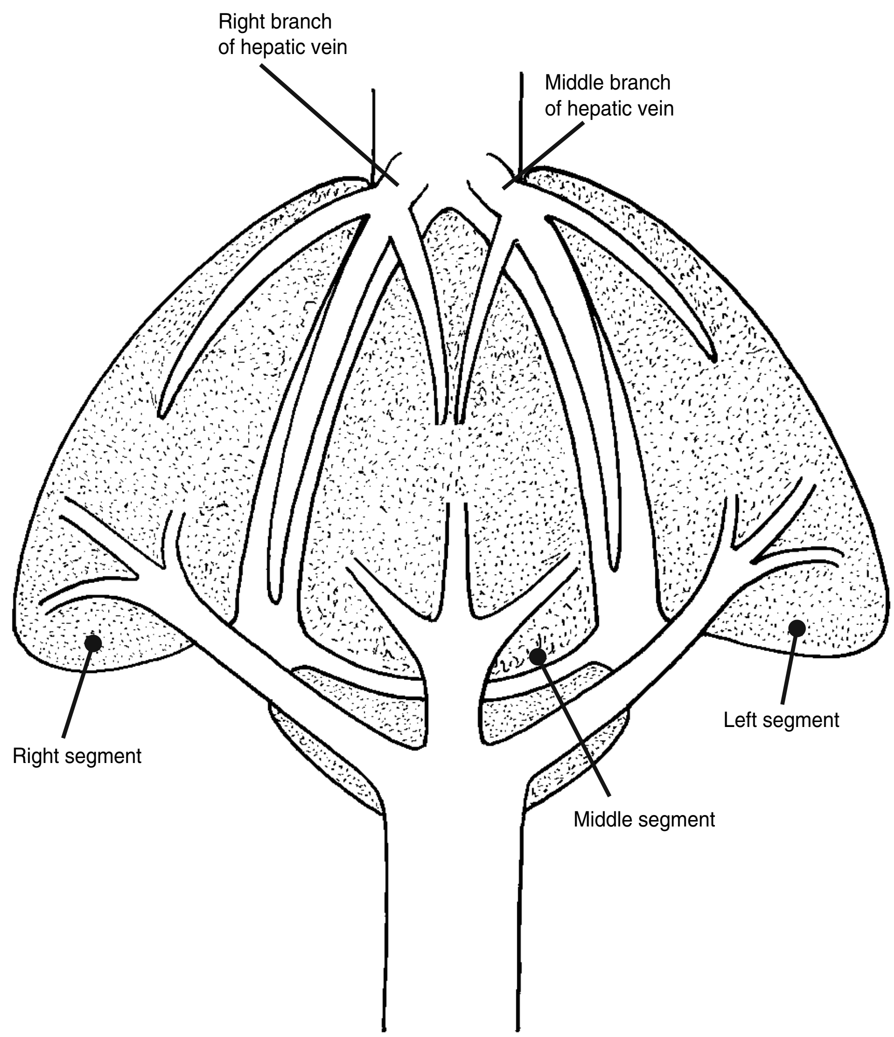


Fig. 2.3. Relationship between liver segments and vessels

Intersegmental Planes (Fig. 2.4)

The intersegmental plane between the right and middle segments is determined by the vena cava and the right hepatic vein. Likewise, the intersegmental plane between the middle and left segments is determined by the IVC and the middle hepatic vein.

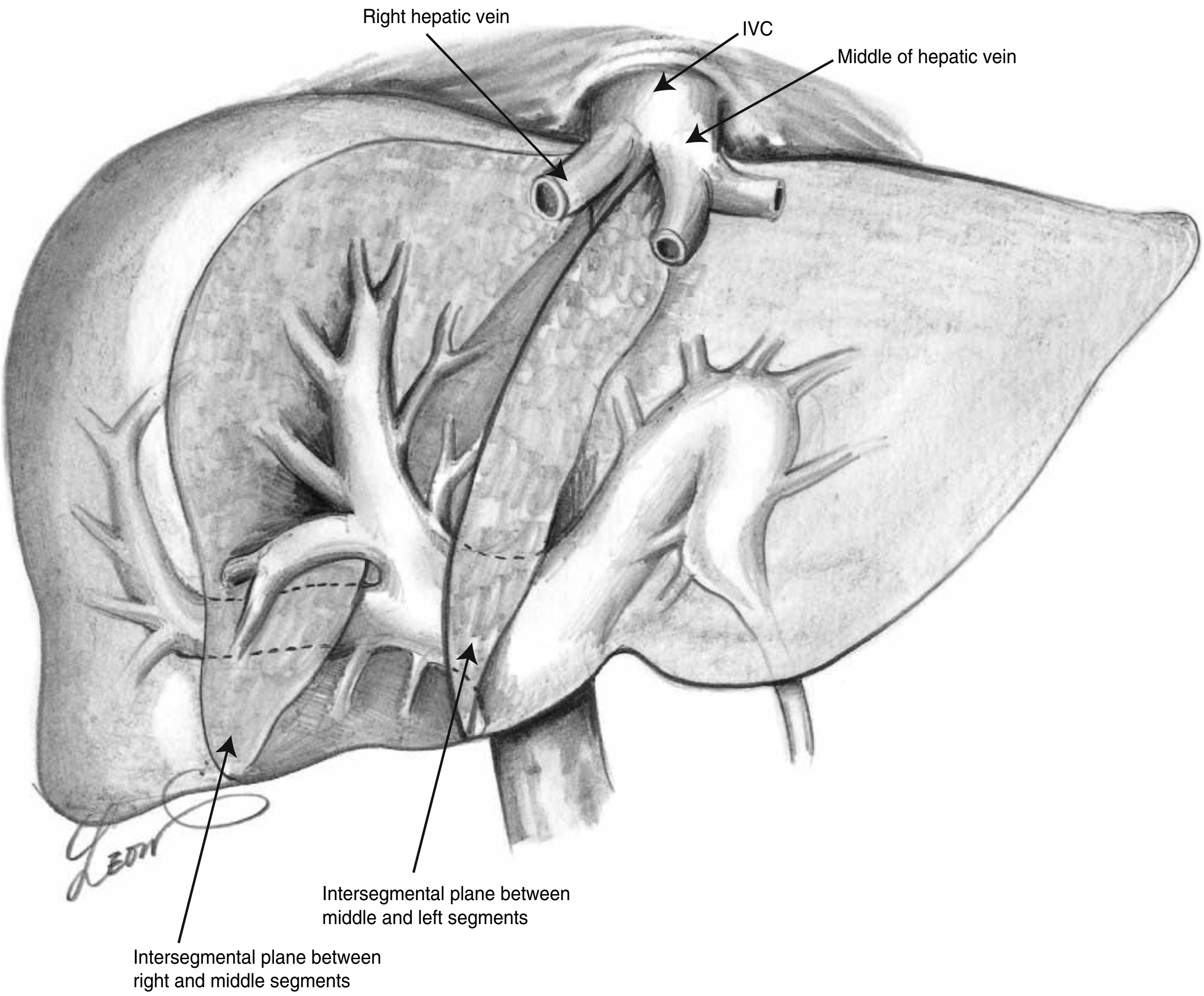


Fig. 2.4. Intersegmental planes

Caudate Area (Figs. 2.1 and 2.2)

As shown in Fig. 2.1, the caudate area is nourished by several thin Glissonean pedicles directly from the primary branch at the hepatic hilum. Figure 2.2 shows that the caudate area surrounds the IVC and has several short hepatic veins. Note that none of the segments are adherent to the IVC.

Border Between the Segments and the Caudate Area

Anterior Paracaval Triangle and Lateral Paracaval Triangle (Figs. 2.5 to 2.7)

The borders of each of the three segments and caudate area are indicated by line A-B in Fig. 2.5. Point A indicates the point of the superior part of the IVC, and point B is the point of bifurcation of the right primary Glissonean pedicle. All segments and the caudate area touch on line A-B. The border between the left segment and the caudate area is determined by the anterior paracaval triangle (triangle ABC in Fig. 2.5). Point C is the root of the left segmental branch.

The border between the right segment and the caudate area is determined by the lateral paracaval triangle (triangle ABD in Fig. 2.5). Point D is the edge of the caudate process.

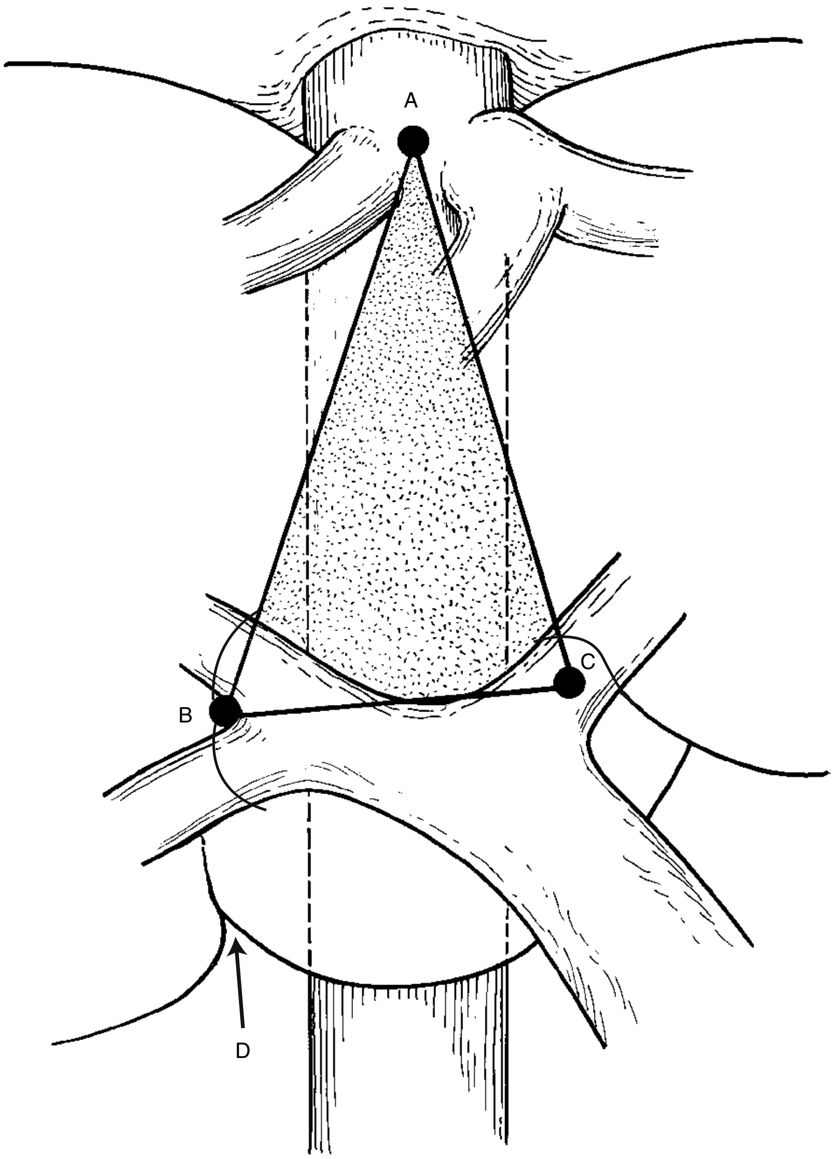


Fig. 2.5. Schema of anterior paracaval triangle

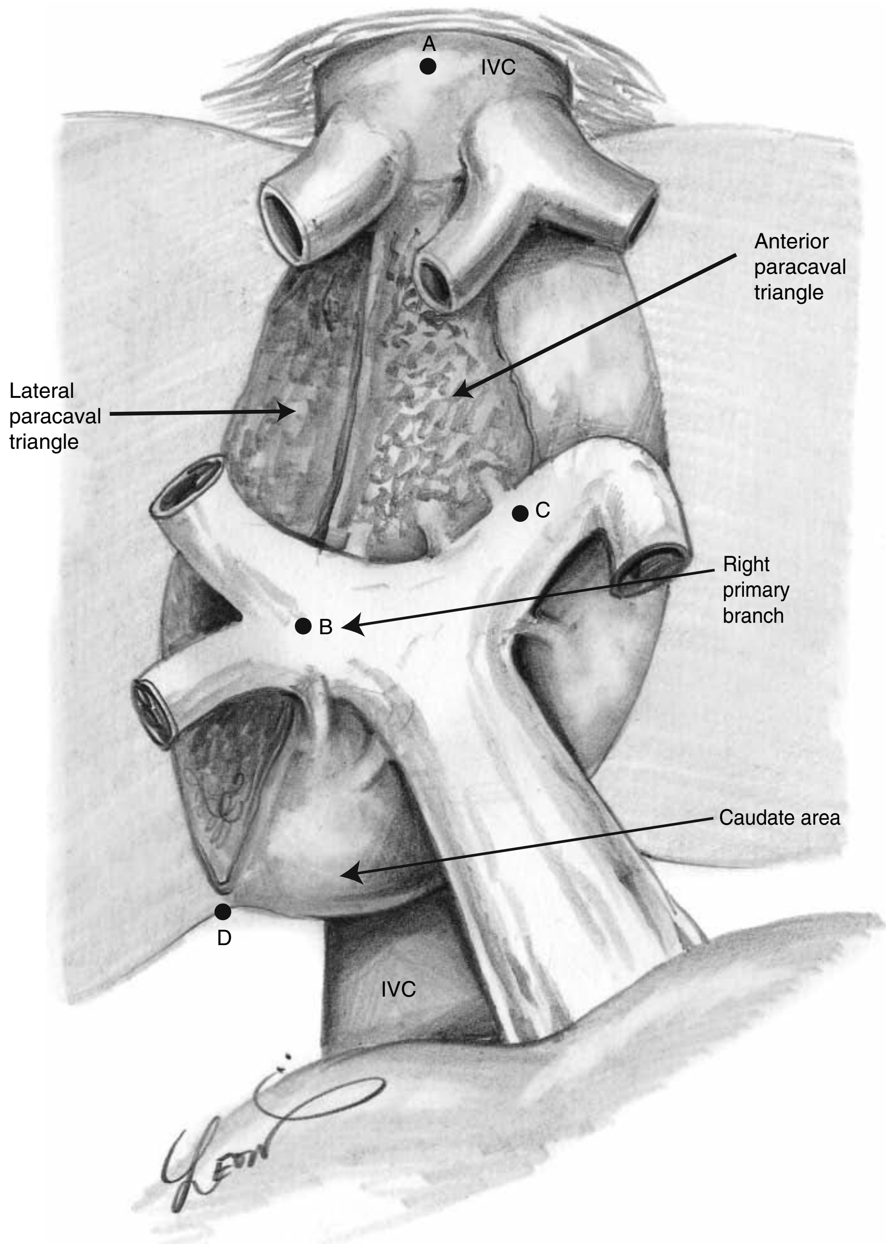


Fig. 2.6. Paracaval triangles and caudate area

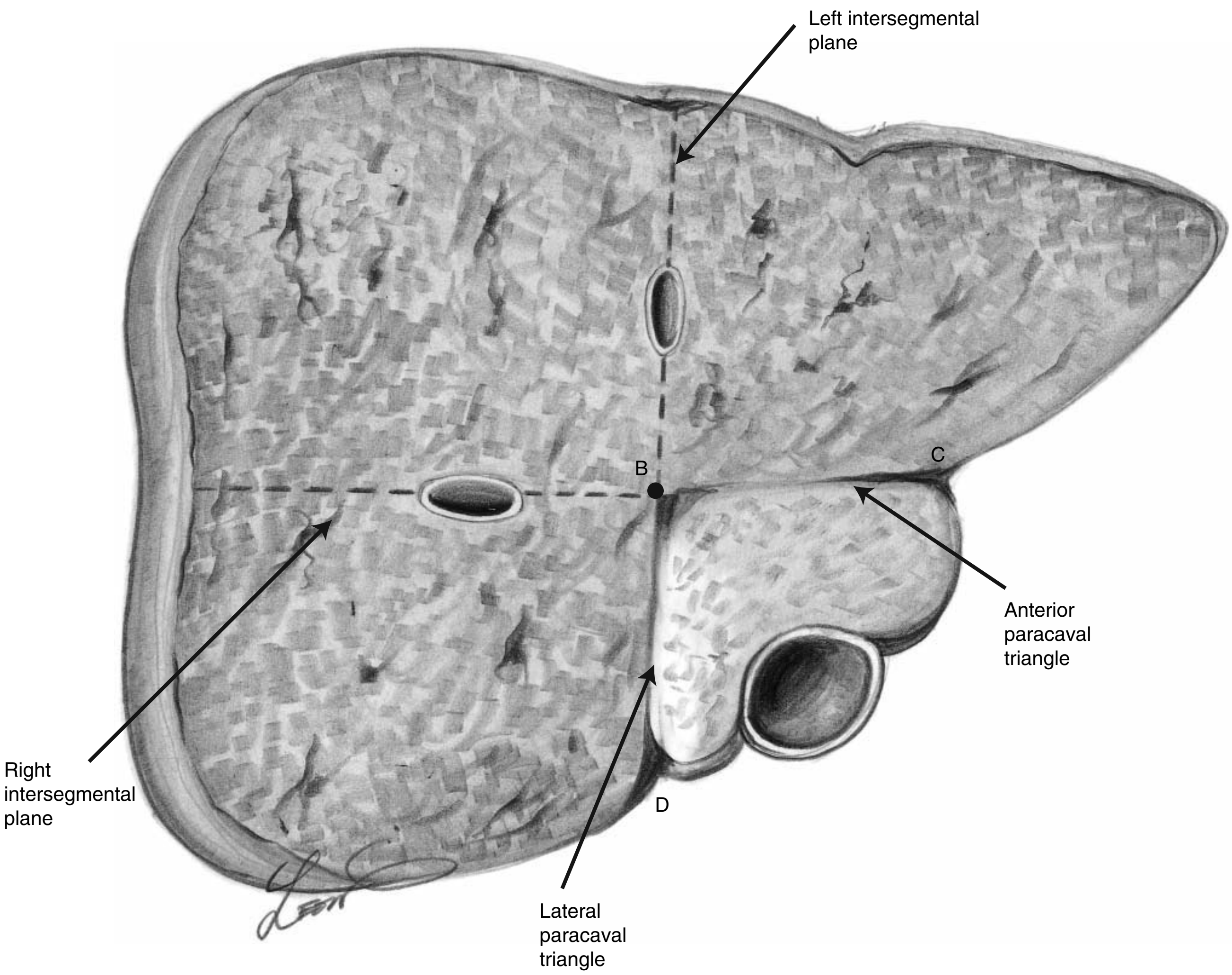


Fig. 2.7. Intersegmental planes between the three segments and the caudate area

Comparison of Takasaki's Segmentation with Other Classifications

The *General Rules for the Clinical and Pathological Study of Primary Liver Cancer*, edited by the Liver Cancer Study Group of Japan, adopted the classification of five segments according to Healey: the posterior and anterior segments of the right lobe, the lateral and medial segments of the left lobe, and the caudate area.

These five segments are further subdivided into two areas: superior and inferior areas.

When compared with our classification of three segments, the posterior segment corresponds to the right segment, the anterior segment to the medial segment, and the left lobe to the left segment (Table 1). In the *General Rules*, the left lobe is divided into two segments. Regarding the distribution of the

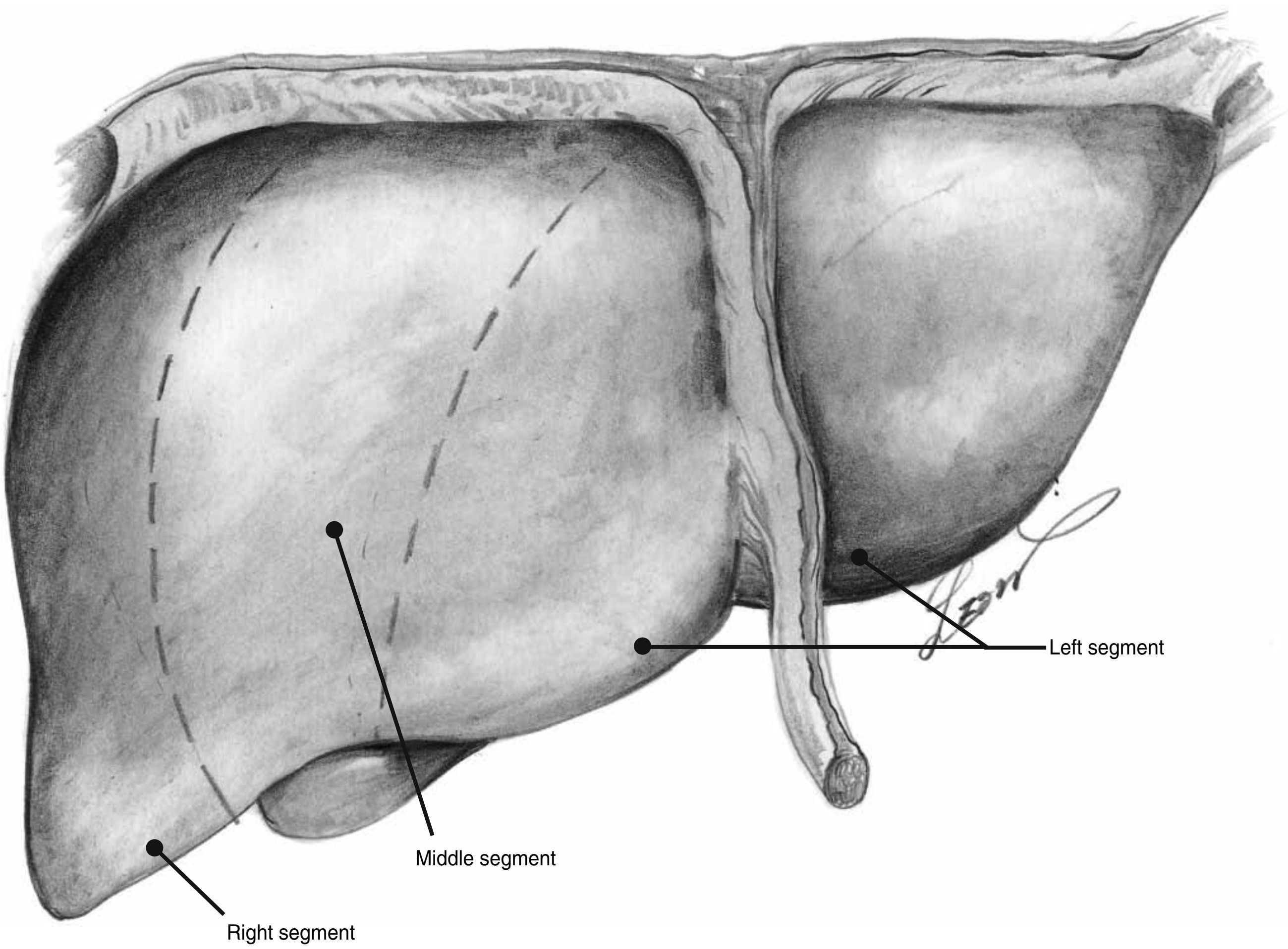


Fig. 2.8. Our segment classification

Table 1. Comparison of classification systems

	Healey's		Couinaud's	Takasaki's
Right lobe	Posterior segment	Post inferior area	SVI	Right segment
		Post superior area	SVII	
	Anterior segment	Anterior inferior area	SV	Middle segment
		Anterior superior area	SVIII	
Left lobe	Medial segment	Medial superior area	SIV	Left segment
		Medial lateral area	SIII	
	Lateral segment		SII	
Caudate lobe		Caudate process	SI	Caudate area
		Caudate left portion		
		Caudate right portion		

portal tree, there is one secondary branch giving rise to several tertiary branches. This pattern is similar to that of the right and medial segments. The term "left lobe" is not used in the *General Rules* as opposed to the term "right lobe". Rather, the term "left lobe" is used to correspond to the left segment, as one of three segments: left, right, and middle.

In recent years, Couinaud's segmentation has been utilized for convenience. However, this segmentation does not always correspond to the distribution of the Glissonean pedicle. Each Couinaud's segment does not necessarily contain only one single tertiary branch. In many individuals, it is difficult to evaluate which Glissonean pedicle branch (or how many branches) supplies one Couinaud's segment. The idea of Couinaud's segmentation still has utilitarian value because of its simplicity. One Couinaud's segment consists of several cone units (see Fig. 4.1). Compared with my segmentation, Couinaud's S2, S3, and S4 correspond to the left segment, S5 and S8 to the middle segment, and S6 and S7 to the right segment.

3 Ramification of the Tertiary Branches from the Secondary Branches of the Glissonean Pedicle

Basic Ramification Pattern of the Tertiary Branches

The ramification pattern of the tertiary branches is different from individual to individual and lacks regularity. In general, vessels develop in pairs, but the growth pattern of the tertiary branches of the Glissonean pedicle is different, because several pairs of branches, usually two to eight, appear simultaneously.

The secondary branches do not necessarily subdivide into two tertiary ones; sometimes there are two and, sometimes there are more, all commonly with the same diameter. Usually from two to eight tertiary branches ramify from a secondary branch. If there are eight branches, one or more of such branches are derived together from the same secondary branch, and various numbers of tertiary offshoots thus arise.

Several tertiary branches originate from each segmental branch inside the liver. Therefore, these tertiary branches are hidden from view, especially in the right and middle segments. About half of such branches are visible in the left segment.

Position of the Glissonean Pedicle Tree Inside the Segments

Figures 3.1, 3.2, and 3.3 show how the numbers of tertiary branches vary according to three different patterns of segmental branch length. When the trunk of the secondary branch is short, there are few tertiary branches, but their diameter is sizable (pattern A; Fig. 3.1).

When the trunk of the secondary branch is of medium length, there are several tertiary branches (pattern B; Fig. 3.2).

When the secondary branch is long, there are many (but not more than eight) narrow tertiary branches (pattern C; Fig. 3.3).

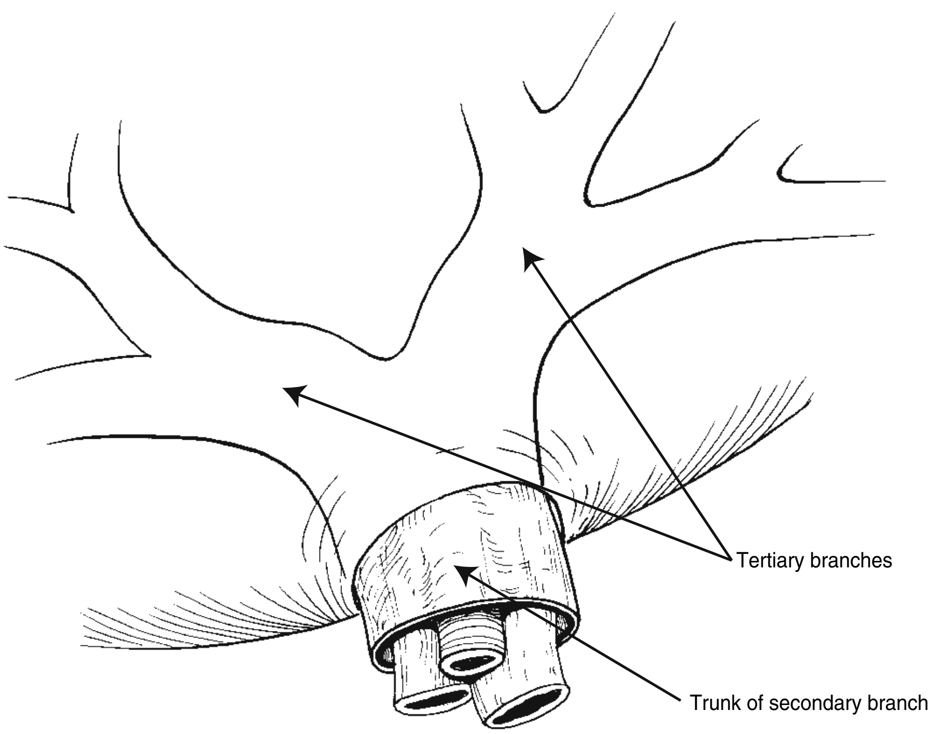


Fig. 3.1. Number of tertiary branches (pattern A)

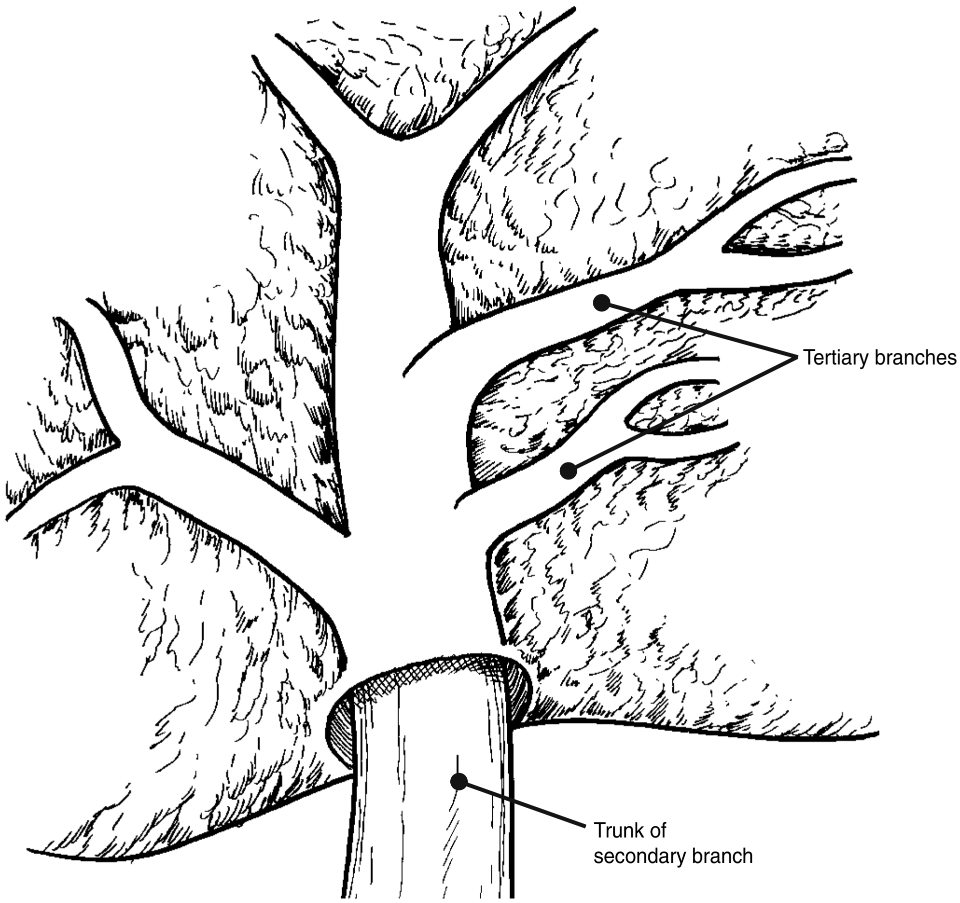


Fig. 3.2. Number of tertiary branches (pattern B)

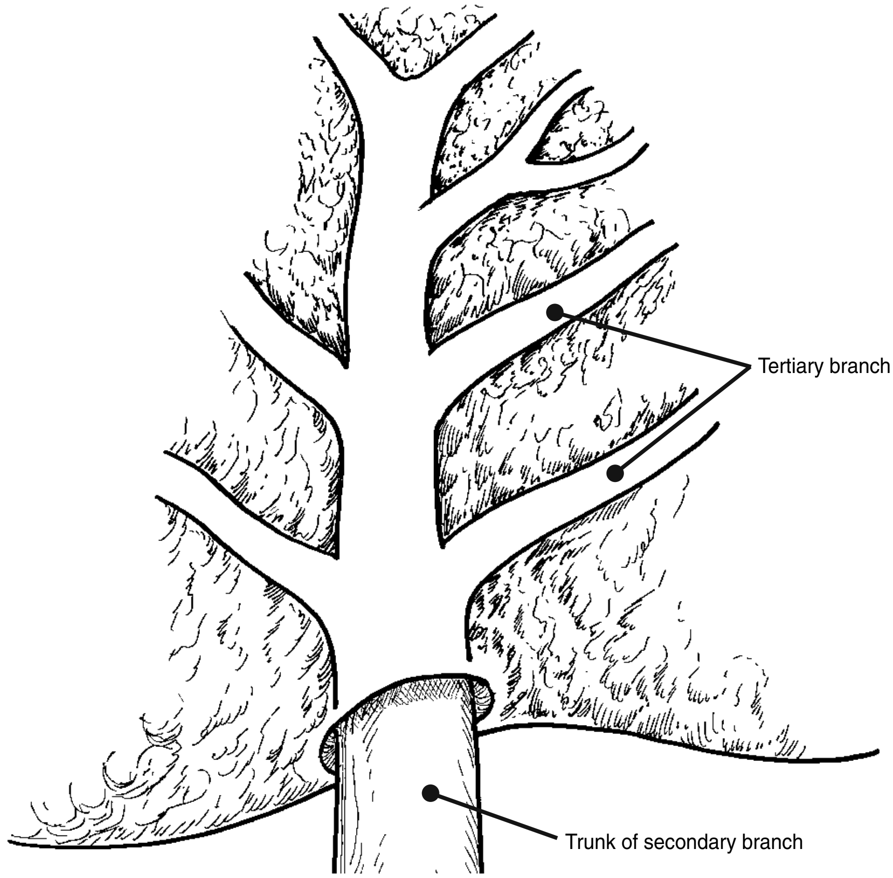


Fig. 3.3. Number of tertiary branches (pattern C)

Relative Positions of the Glissonean Pedicles and the Hepatic Vein

The relative positions of the hepatic vein and Glissonean pedicles differ depending upon their location in the liver. In the upper part of the liver, almost all branches of the Glissonean pedicle tree intersect those of the hepatic vein, while in the lower part of the liver almost all branches of the Glissonean pedicle tree tend to run parallel to the hepatic vein (Fig. 3.4a, b).

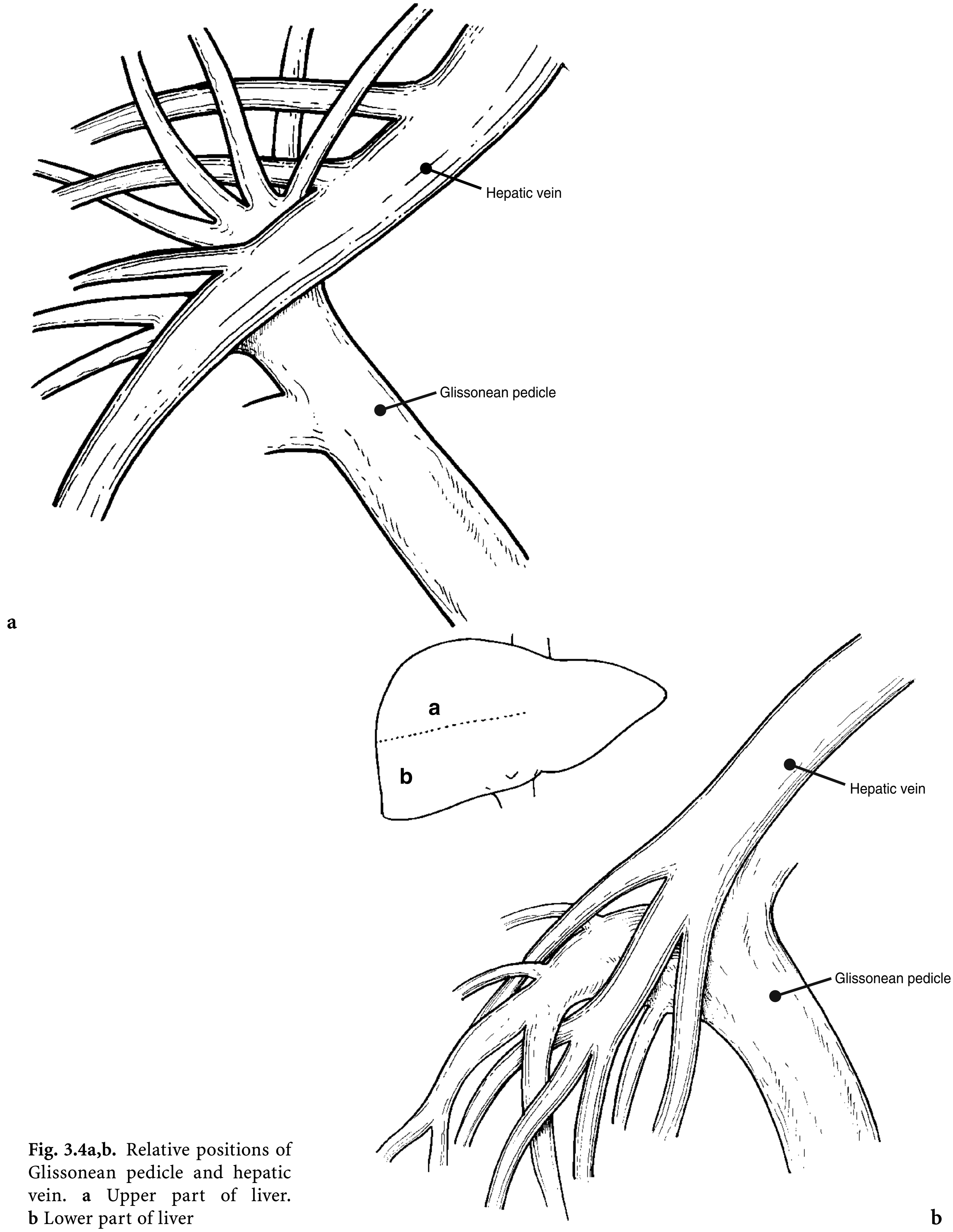
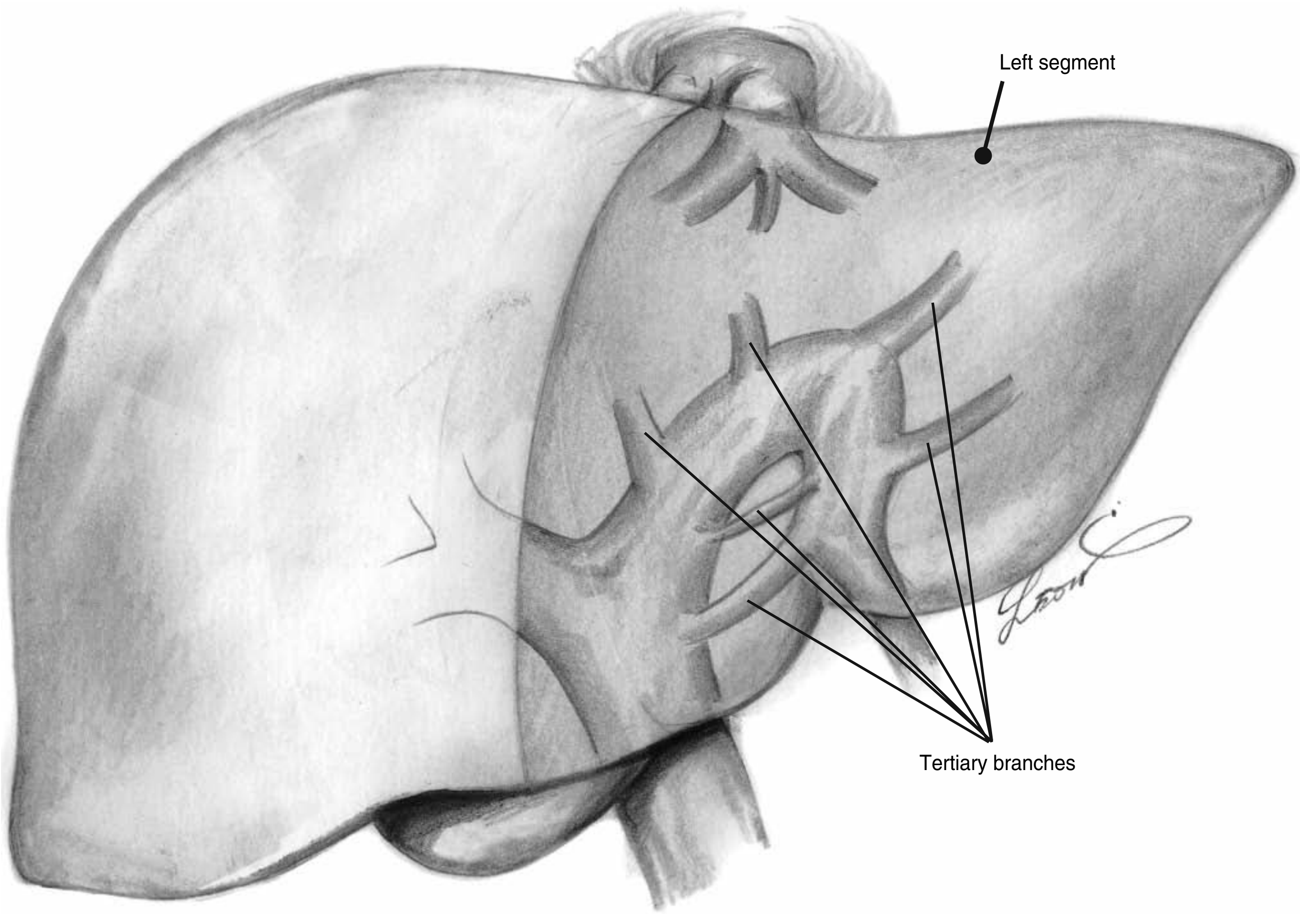


Fig. 3.4a,b. Relative positions of Glissonean pedicle and hepatic vein. **a** Upper part of liver. **b** Lower part of liver

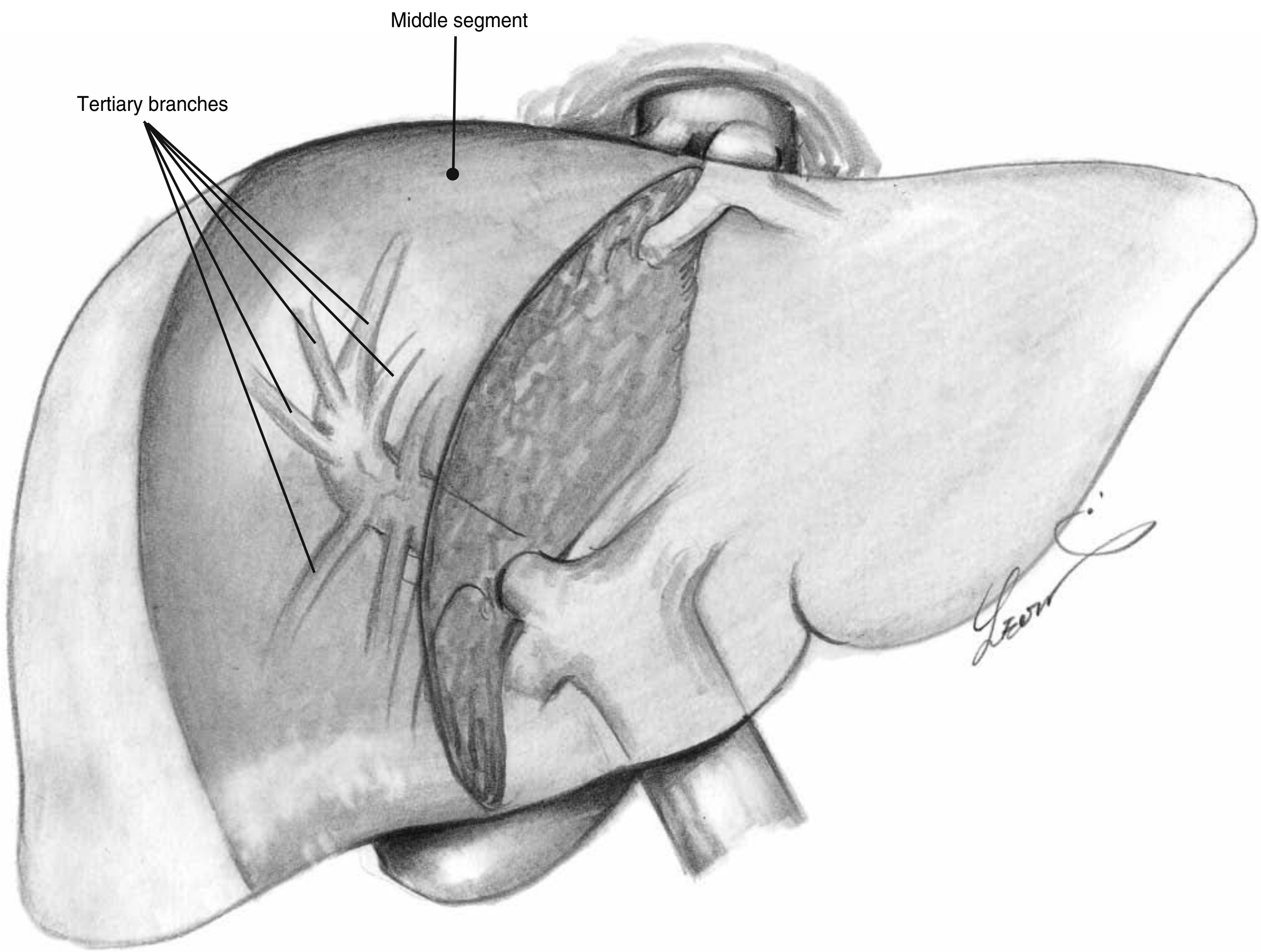
Location of the Segmental Branch of the Glissonean Pedicle in Each of the Three Segments

Figure 3.5a–c shows schemas of the ramification patterns of tertiary branches from the segmental branch in each segment. In these schemas, the view would actually be covered by the liver parenchyma and the round ligament is pulled down. In the left segment (Fig. 3.5a), some tertiary branches differ from the left segmental branch in that the branches protrude in several directions, though not down nor back, but somewhat like the needles of a hedgehog. Fig. 3.5b and c show the segmental branches in the middle and the right segments, respectively.



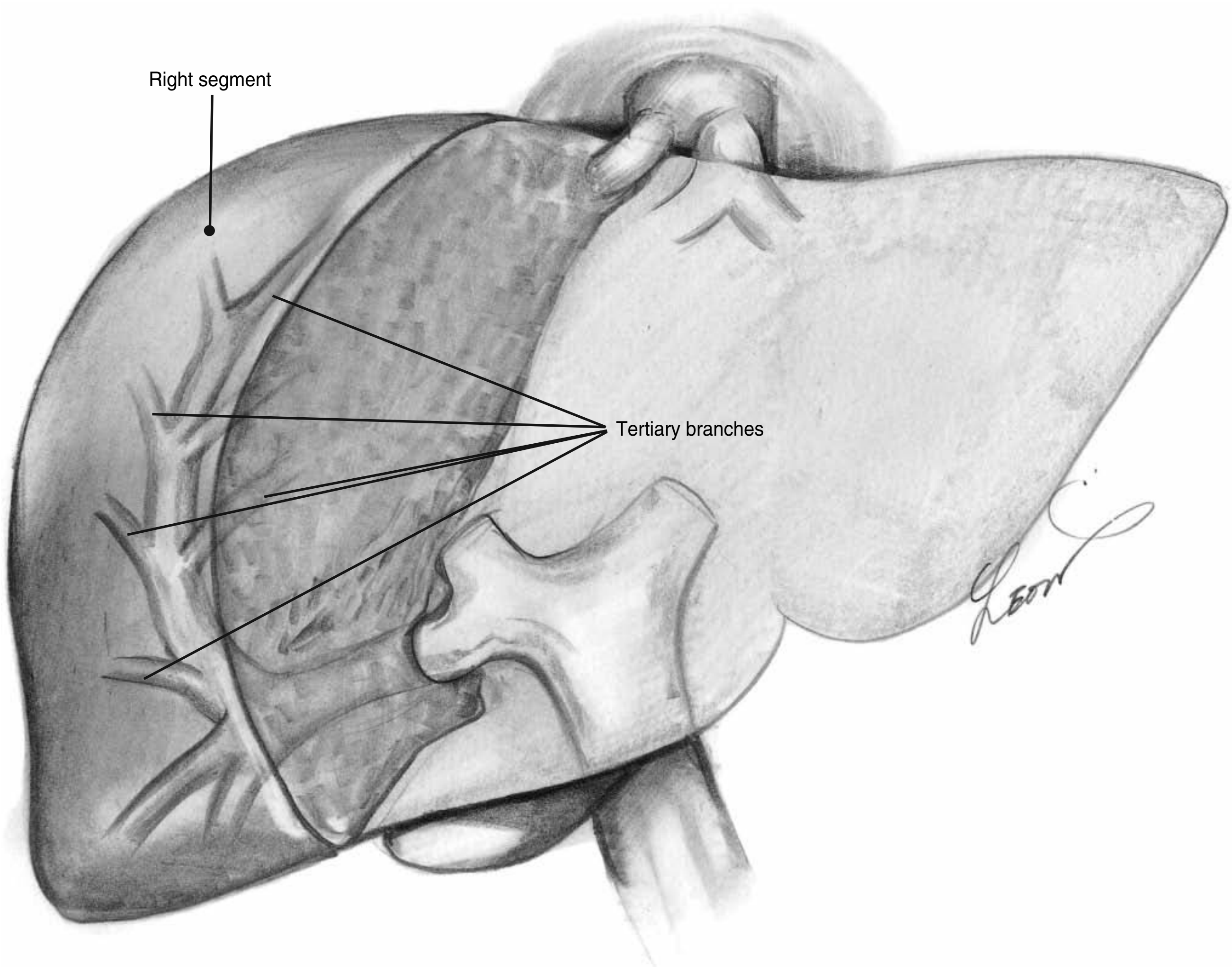
a

Fig. 3.5a. Segmental branches and tertiary branches of left segment



b

Fig. 3.5b. Segmental branches and tertiary branches of the middle segment



c

Fig. 3.5c. Segmental branches and tertiary branches of the right segment

4 Concept of the Cone Unit

The three liver segments are each separated into smaller areas according to the branching pattern of the tertiary branch. The area fed by each of the tertiary branches is called a “cone unit”. The base of each cone unit lies on the surface of the liver and the apex lies in the origin of these tertiary branches.

Each segment is composed of six to eight cone units. One cone unit is the smallest unit for which a tertiary branch can be transected selectively.

The exact number of cone units in each segment differs from individual to individual, because the branched structure of the Glissonean pedicle (tertiary branching) is rather complicated, with no regularity.

The distribution of cone units in each segment is not always constant, and it is often impossible to determine, because the number of cone units and their distribution differ from person to person. With no fixed rule to follow, a case-by-case approach is required.

Therefore, for convenience, the right and middle segments are each subdivided into two parts: superior and inferior segments, and the left area is subdivided into medial and lateral areas. Usually each part consists of three or four cone units. Figure 4.1 shows a schema of a core unit.

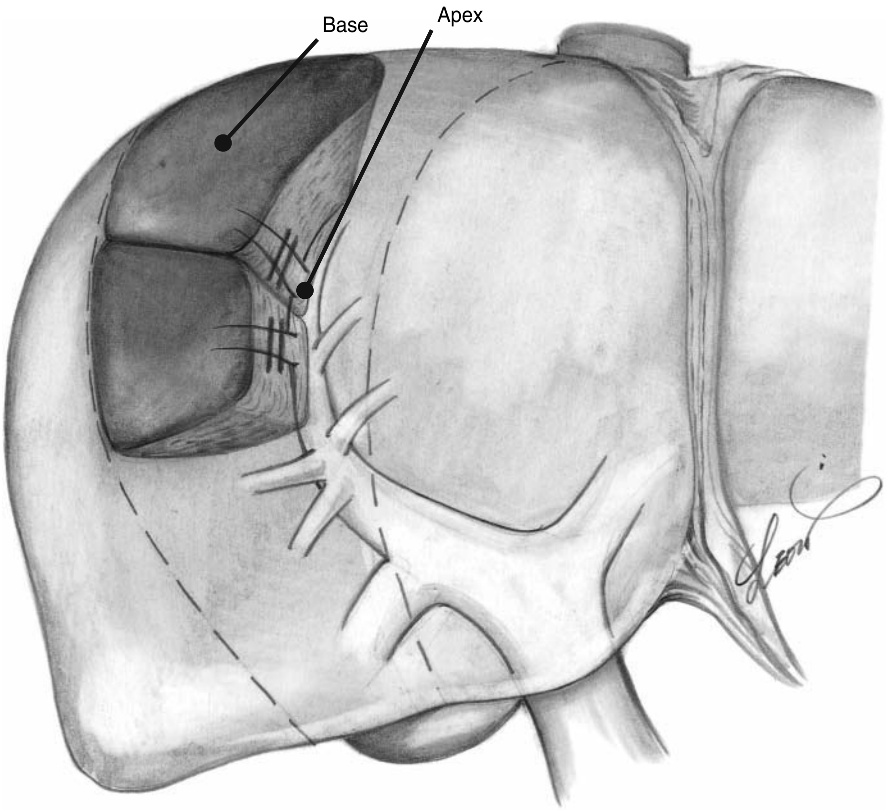


Fig. 4.1. The area nourished by one of the tertiary branches is cone-shaped: the "cone unit." The base lies on the surface of the liver and the apex lies in the direction of the origin of these tertiary branches

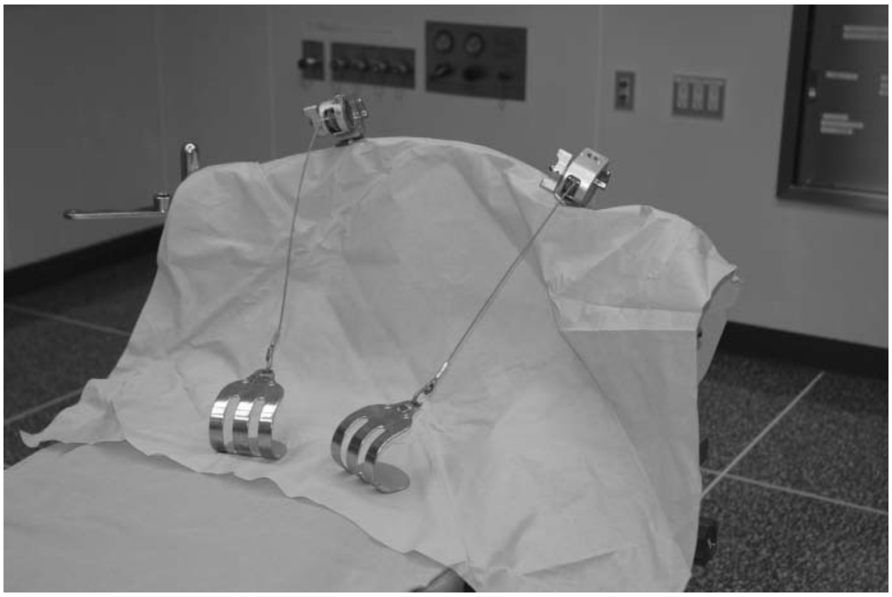
5 Procedures for Hepatic Resection

Laparotomy for Hepatic Resection

How to open and expose the operating field is a very important key for easy operation. I have devised some instruments to facilitate the operation (Fig. 5.1a–c). Various types of incision and exposure are shown in Figs. 5.2, 5.3, and 5.4.

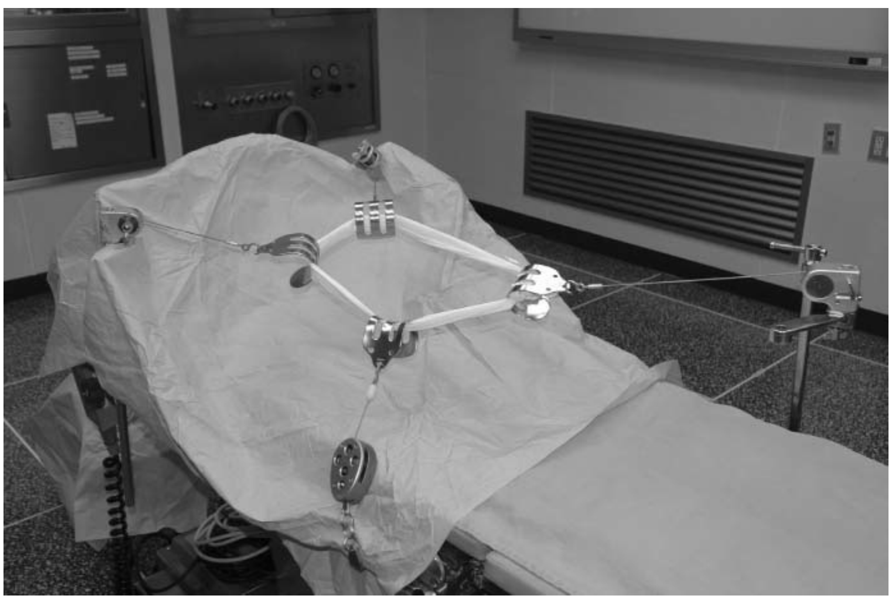
a

Fig. 5.1. a,b Kent retractor (TAKASAGO Ika Kogyo K.K., Tokyo, Japan)



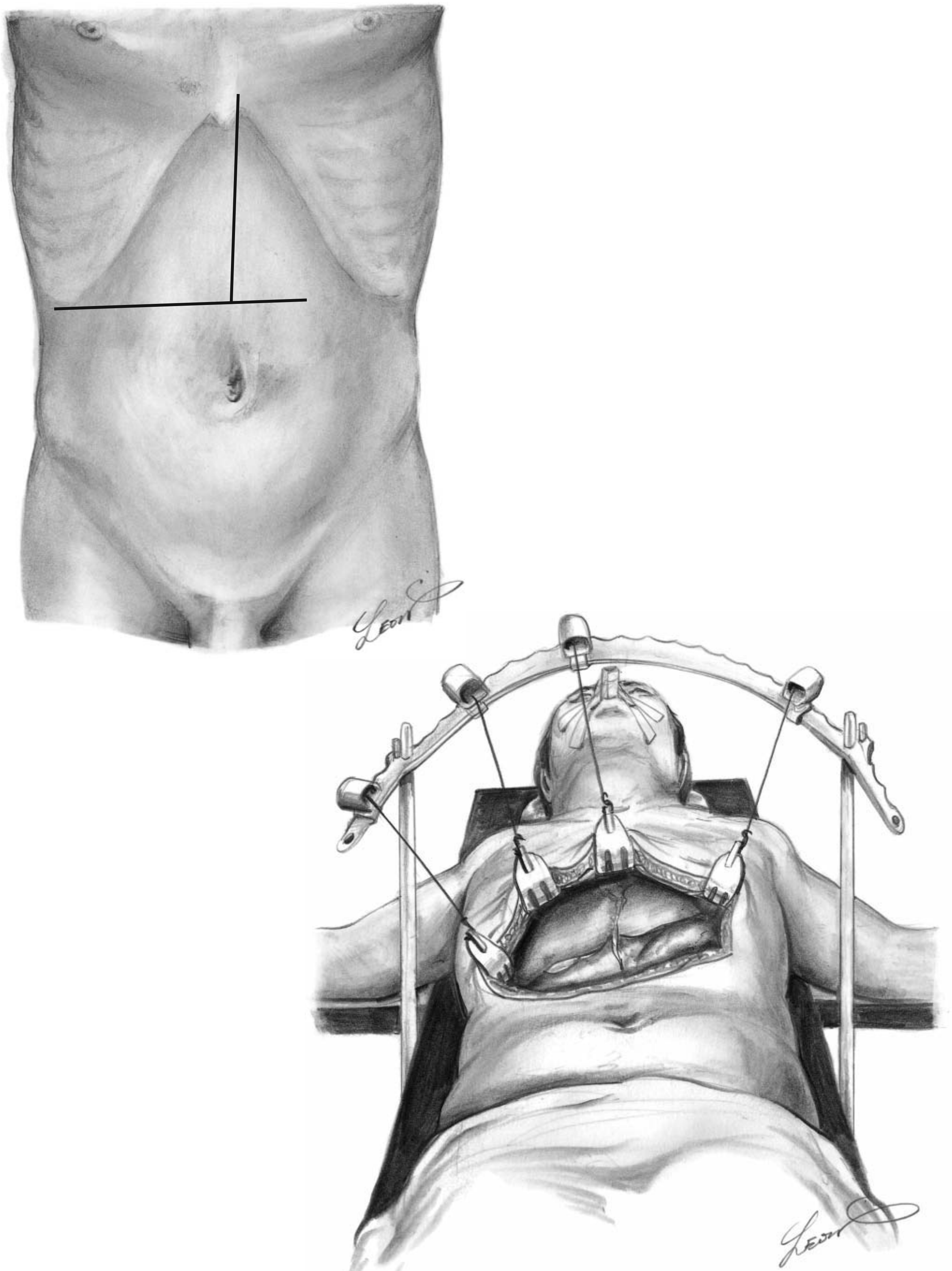
b

c



d

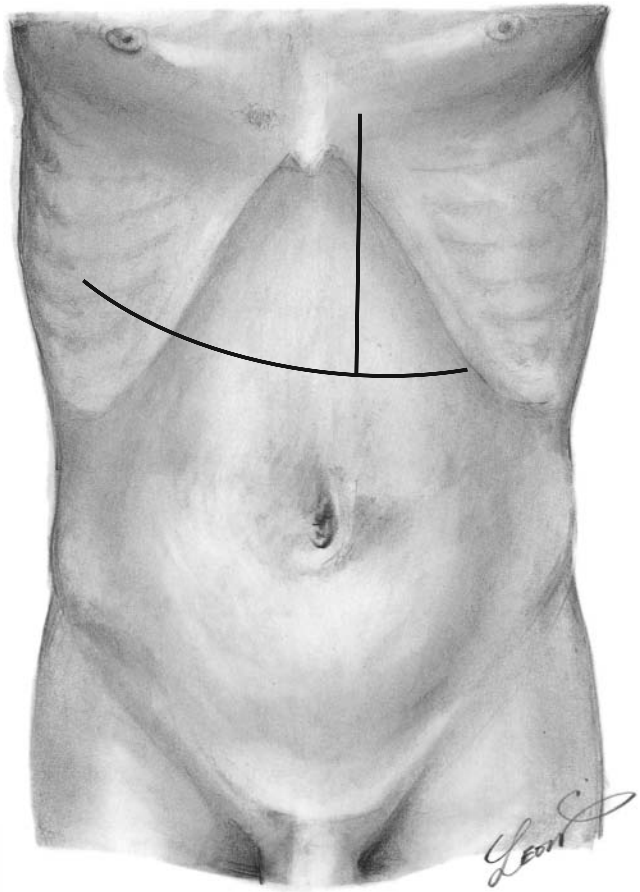
Fig. 5.1. **c** Boomerang retractor; **d** Side retractor



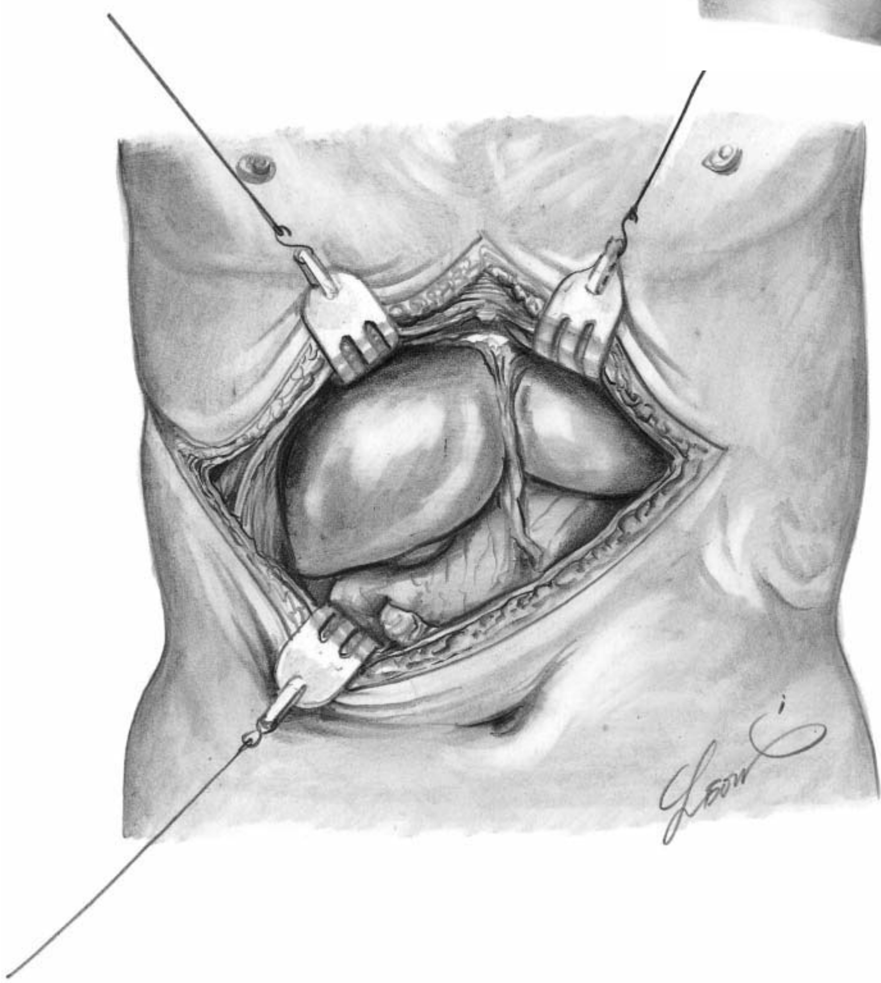
a

b

Fig. 5.2a,b. Reverse T-shaped incision, for standard procedure using the Kent retractor

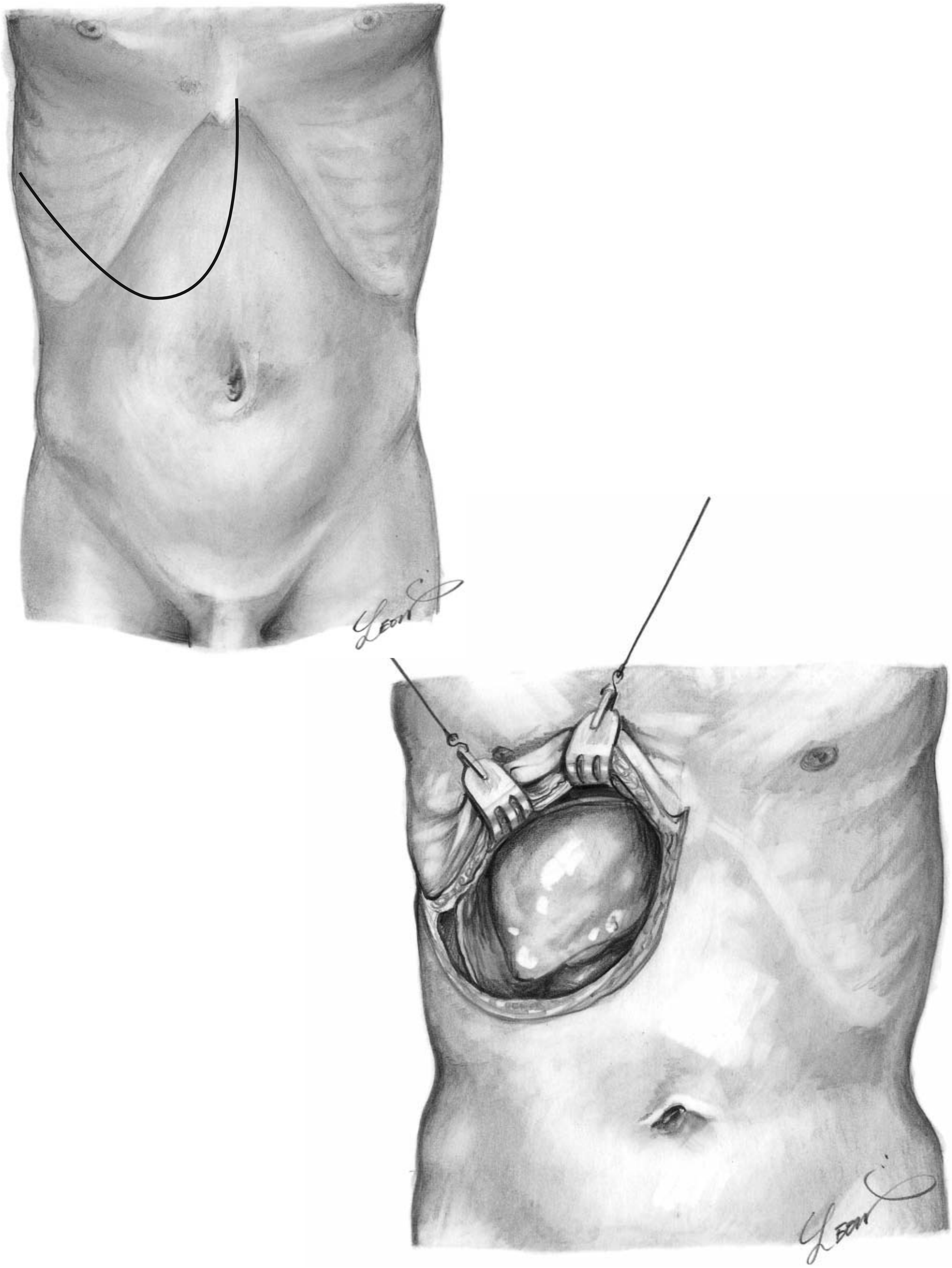


a



b

Fig. 5.3a,b. Laparotomy combined with thoracotomy



a

b

Fig. 5.4a,b. J-shaped incision (only for right-sided hepatic resection)

Basic Principles of Hepatic Segmentectomy Procedure

According to our classification, each liver segment has only one segmental branch of the Glissonean pedicle. The main trunk of the hepatic vein runs along the intersegmental plane. Therefore, to resect any one of the three segments, the first step is to cut the corresponding segmental branch of the Glissonean pedicle and then to dissect the liver parenchyma along the intersegmental plane, ligating and cutting only the branches of the hepatic vein, lest the main trunk of the hepatic vein be injured.

Fundamentally, this technique can be applied to any segmentectomy.

Direction in Which the Segmental Glissonean Pedicles Enter the Liver (Fig. 5.5)

Pull up the round ligament to bring the hilum into full view.

Mentally draw a straight line bisecting the bed of the gallbladder lengthwise and then consider a line drawn perpendicular to it, intersecting at the neck of the gallbladder. The middle segmental branch lies along the imaginary line that cuts through the gallbladder, while the right segmental branch lies along the imaginary line perpendicular to this line. The left segmental branch eventually narrows to become the umbilical portion. Several small branches come out of the two secondary branches and lead to the caudate area.

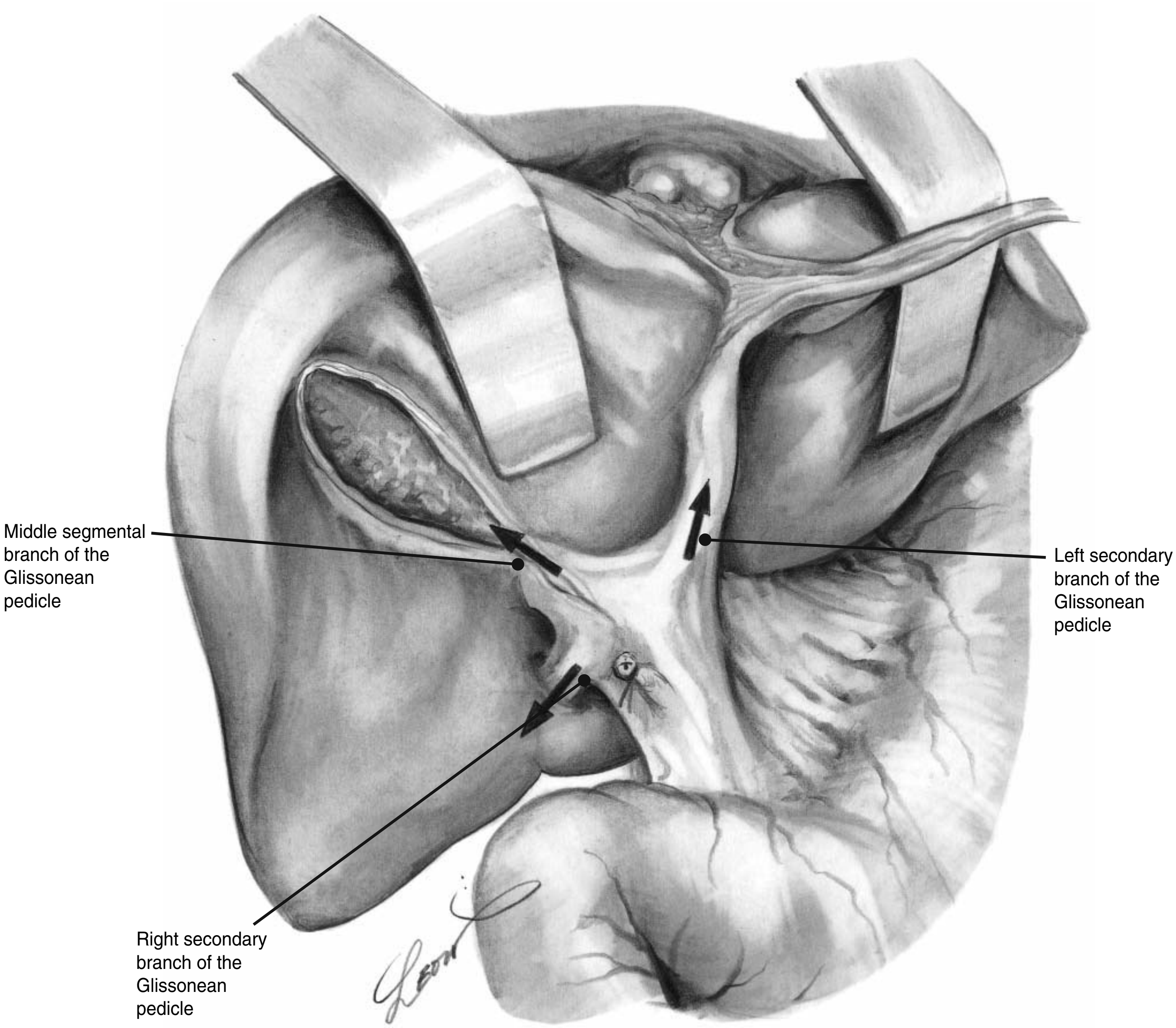


Fig. 5.5. Direction in which Glissonean pedicles enter the liver

Detachment of the Primary Glissonean Pedicle from the Liver Parenchyma at the Hepatic Hilum

The primary Glissonean pedicle is easily detached from the liver parenchyma at the hepatic hilum. Glisson's capsule continues to the peritoneum, which covers the hepatoduodenal ligament. After Glisson's capsule or the peritoneum is cut along the margin of the primary branch of the Glissonean pedicle, the primary branch is easily detached from the liver parenchyma at the hilum.

The origin of the three segmental branches can easily be torn and taped outside the liver without having to incise the liver parenchyma (Fig. 5.6). Structure-wise, the segmental branches continue along the same lines from the inside to the outside of the liver.

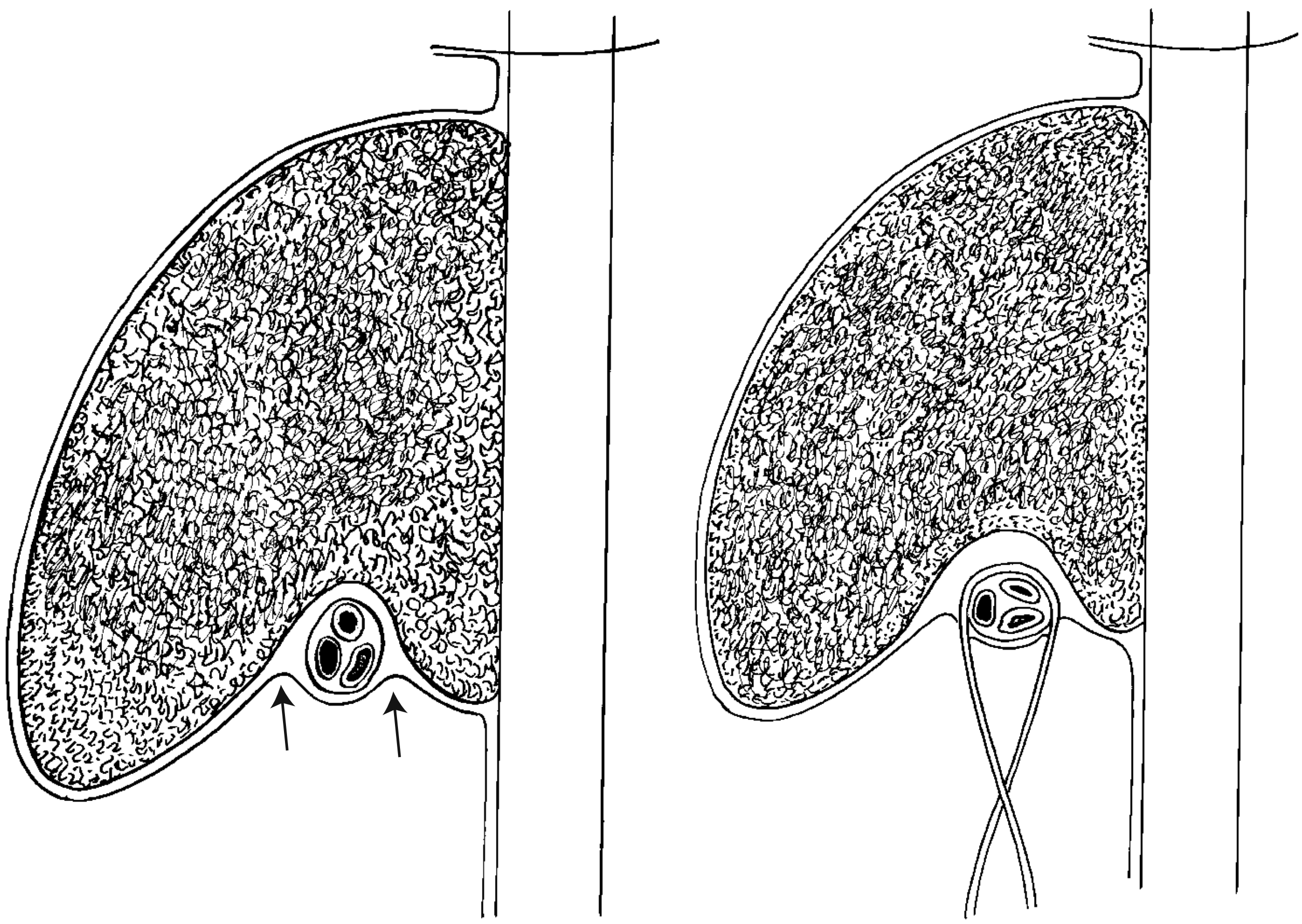


Fig. 5.6. Detachment of the primary Glissonean pedicle from the liver parenchyma at the hepatic hilum

Resection of the Middle Hepatic Segment (Figs. 5.7 to 5.9) (See DVD 1)

The middle segment is located between the right and left segments, with part adjacent to the caudate area. The middle segmental branch feeds this segment, which is drained by the right and middle hepatic veins.

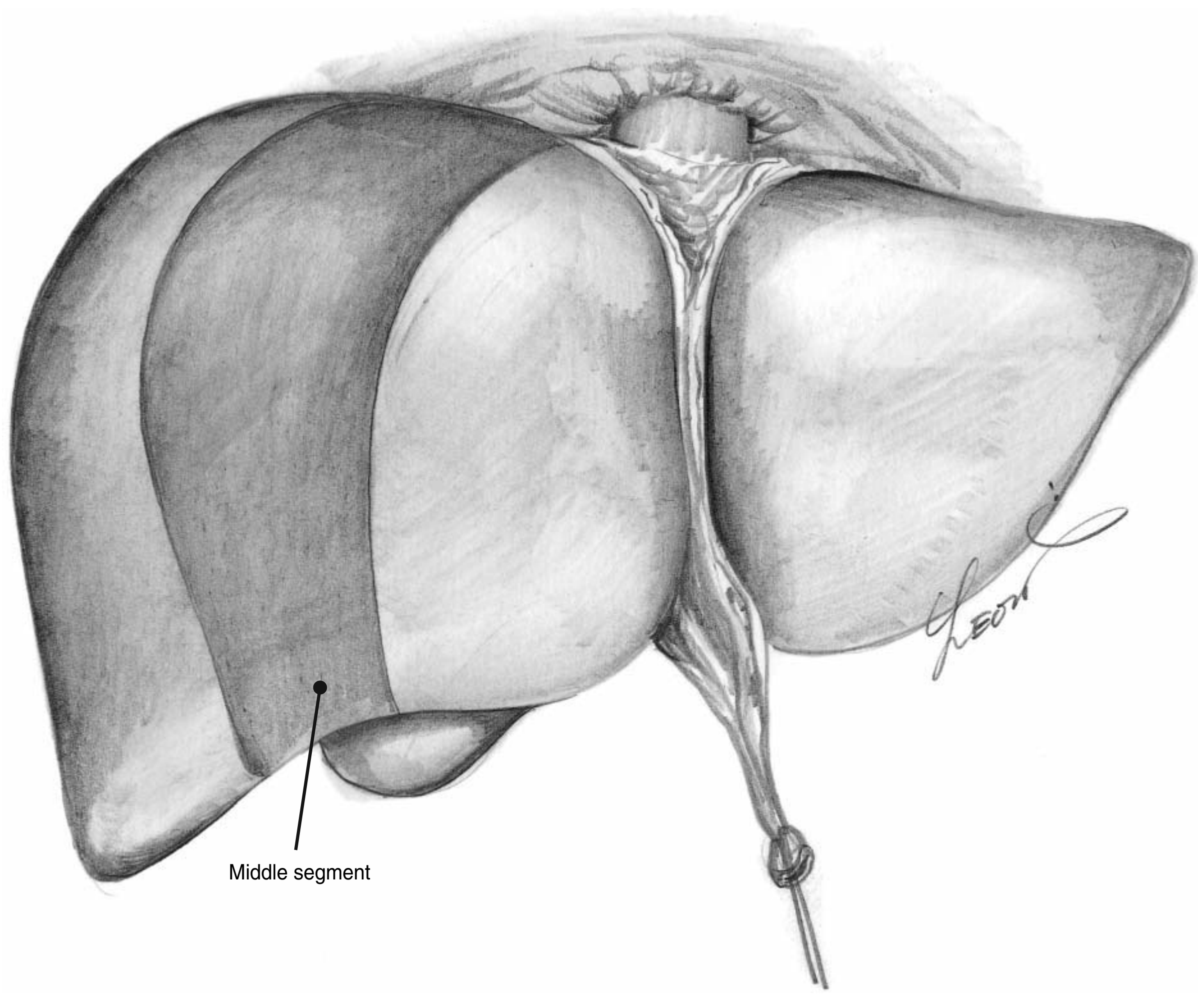


Fig. 5.7. Middle hepatic segment

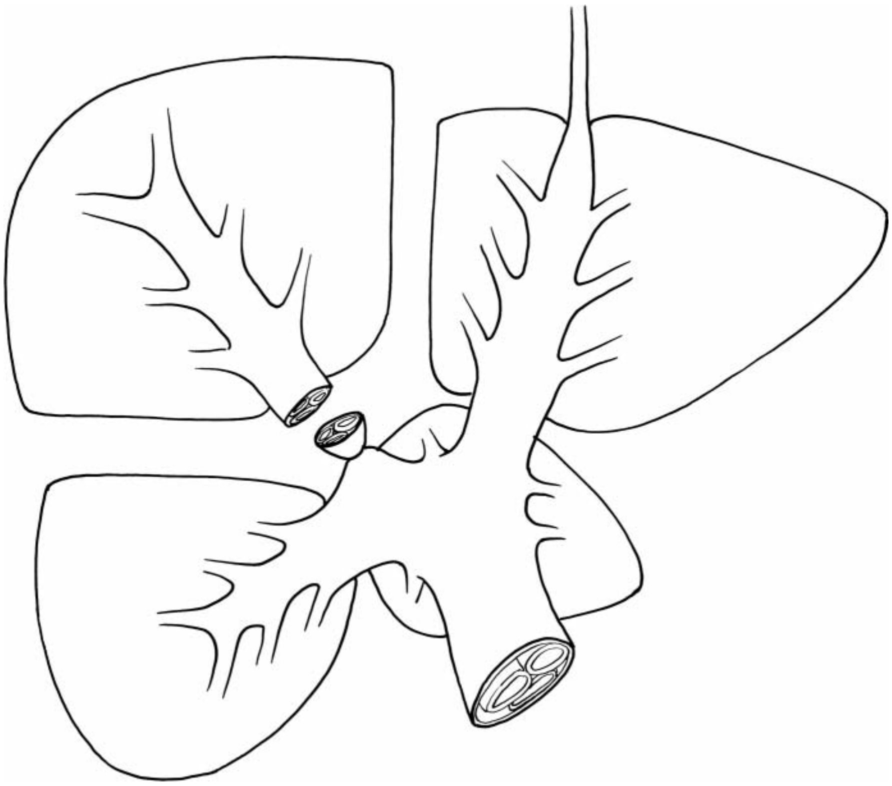


Fig. 5.8. Schema of resection of middle hepatic segment; transection of middle segmental branch

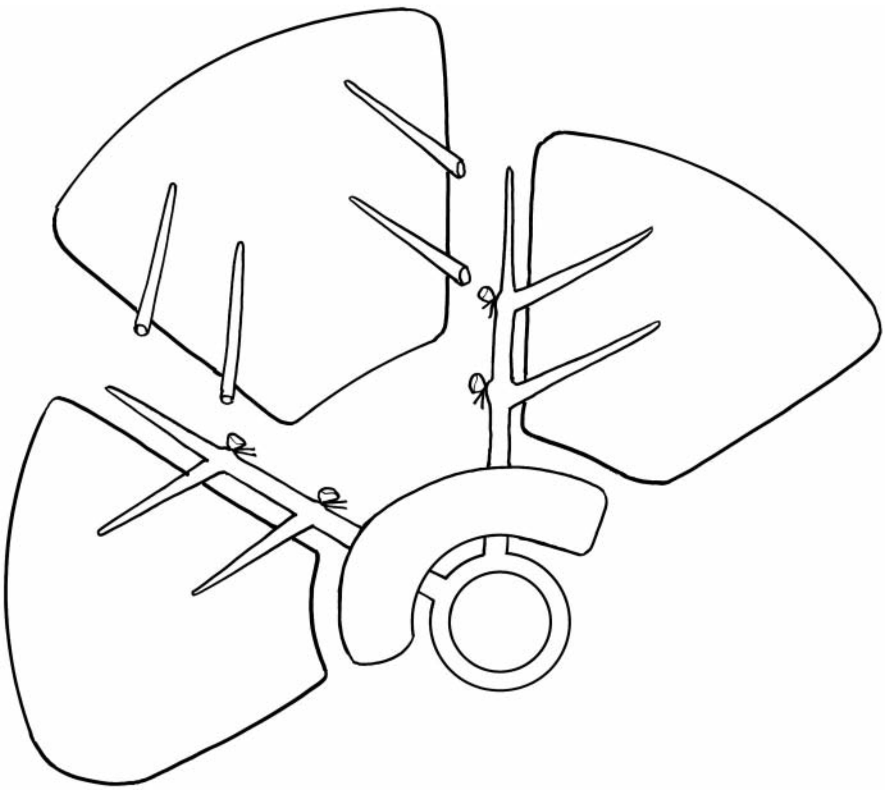


Fig. 5.9. Schema of resection of middle hepatic segment; transection of several branches of right hepatic vein and middle hepatic vein

Incision

Make an upper abdominal reverse "T" incision or a J-shaped thoracoabdominal incision.

Separating the Middle Segmental Branch

See Fig. 5.10. First, perform a cholecystectomy and then remove the connective tissue of the triangle of Calot from the liver bed. The middle segmental branch and the liver parenchyma of the hepatic hilum come into view. All tissue is totally cleared from around the middle segmental branch right up to the point where the middle segmental branch enters the opening of the hepatic hilum.

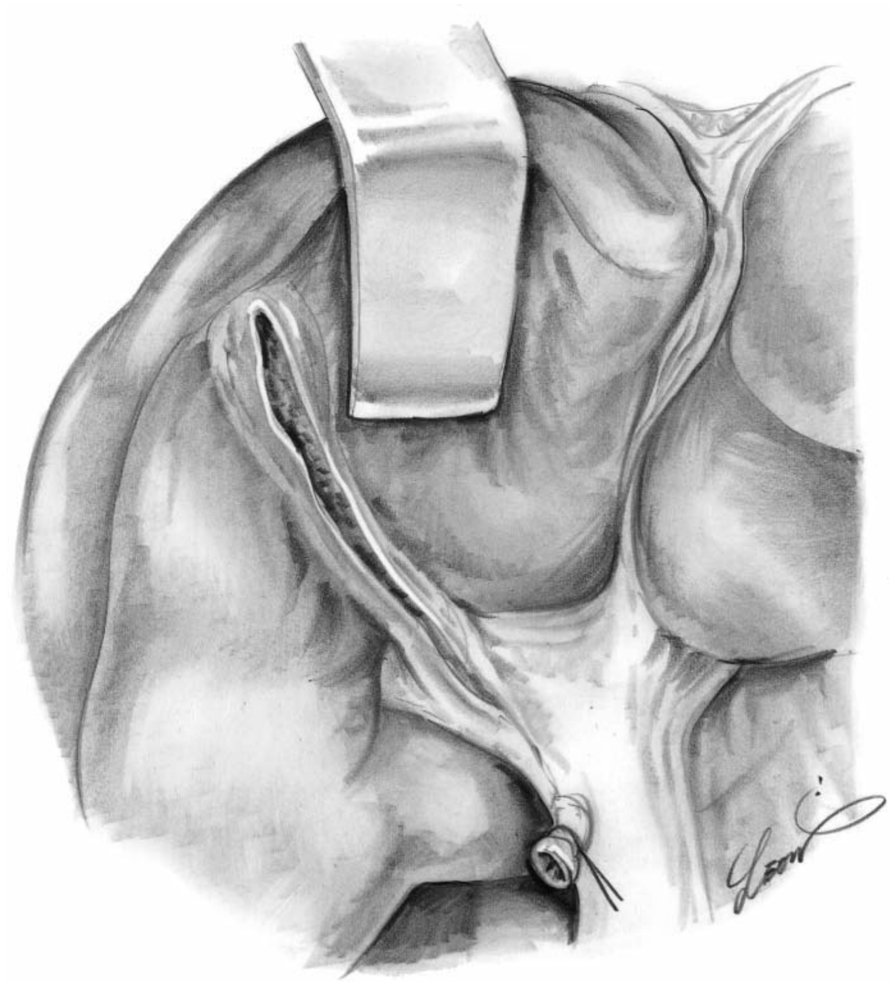


Fig. 5.10. Cholecystectomy was done first

Then (see Figs. 5.11 and 5.12) detach the middle segmental branch from the parenchyma. This must be done by making a very fine line—cut just between the connective tissue of the middle segmental branch and the liver parenchyma. It is imperative to be "just between" in order to prevent bleeding and to keep the operative field clean. When dissection is done "just between" these tissues, there usually appear a few tiny branches. Ligate all of them. The dissection is carried out behind the middle segmental branch in a similar fashion.

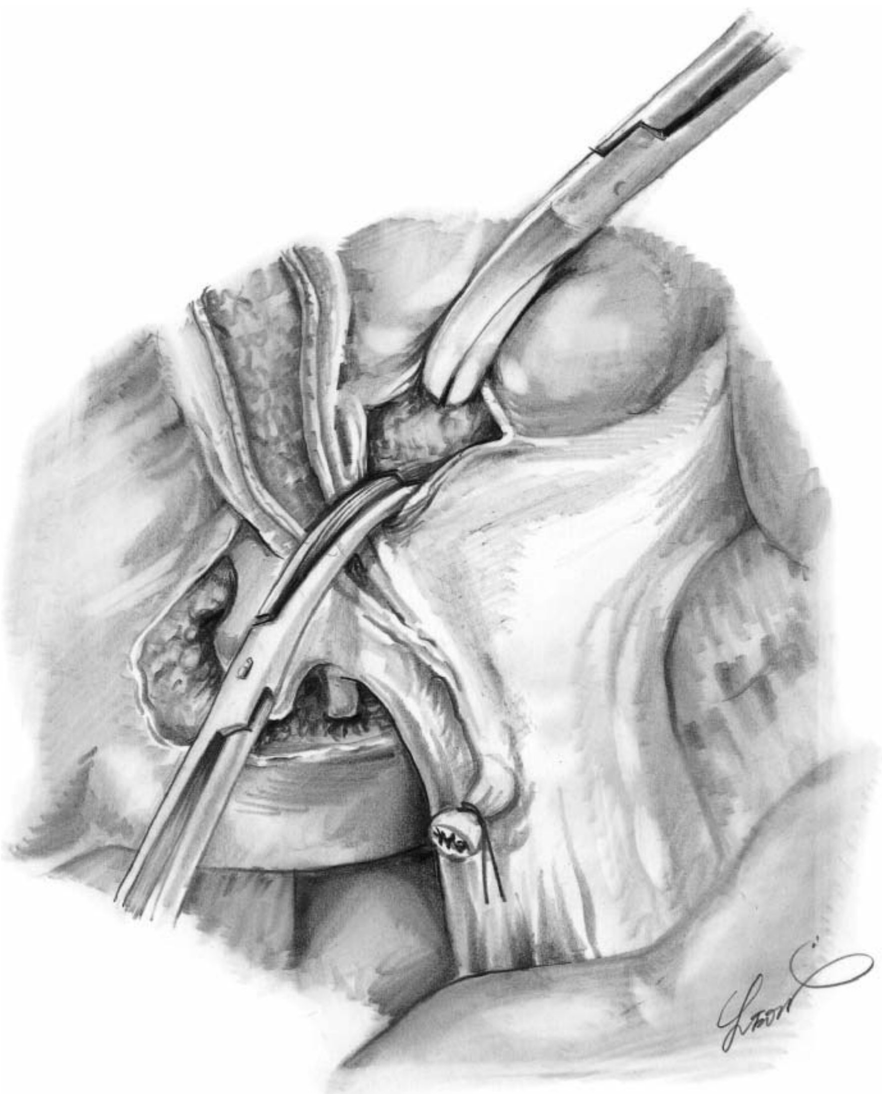


Fig. 5.11. Detaching the middle hepatic branch from the liver parenchyma

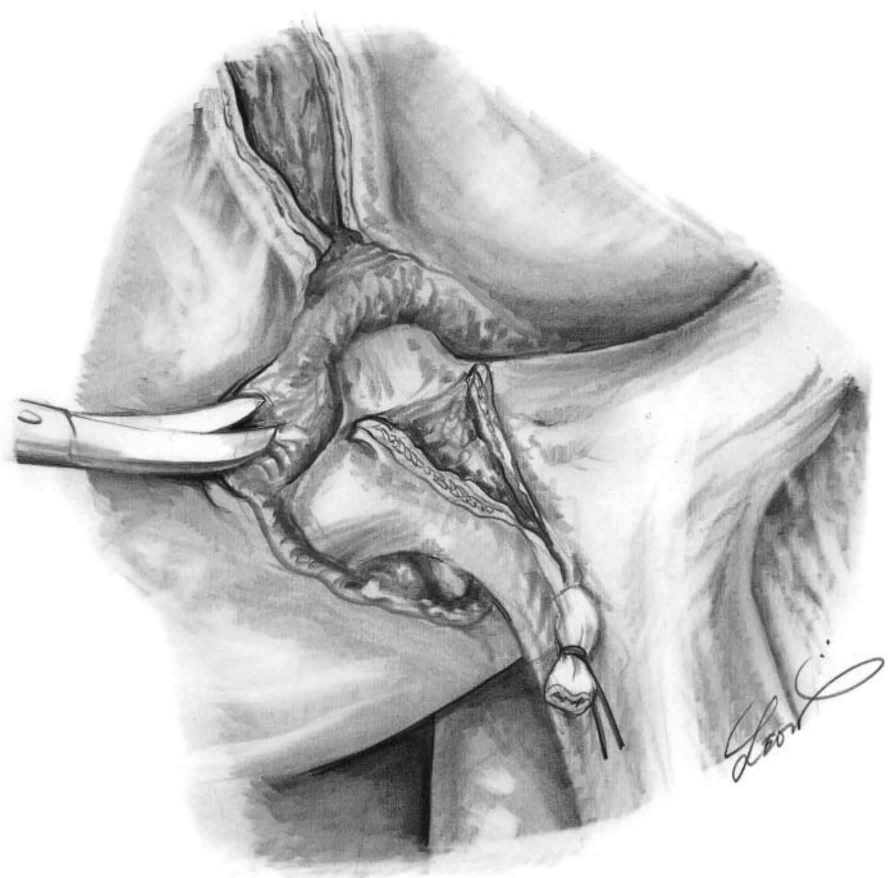


Fig. 5.12. Disection of the liver tissue which covers the middle segmental branch of the Glissonean pedicle

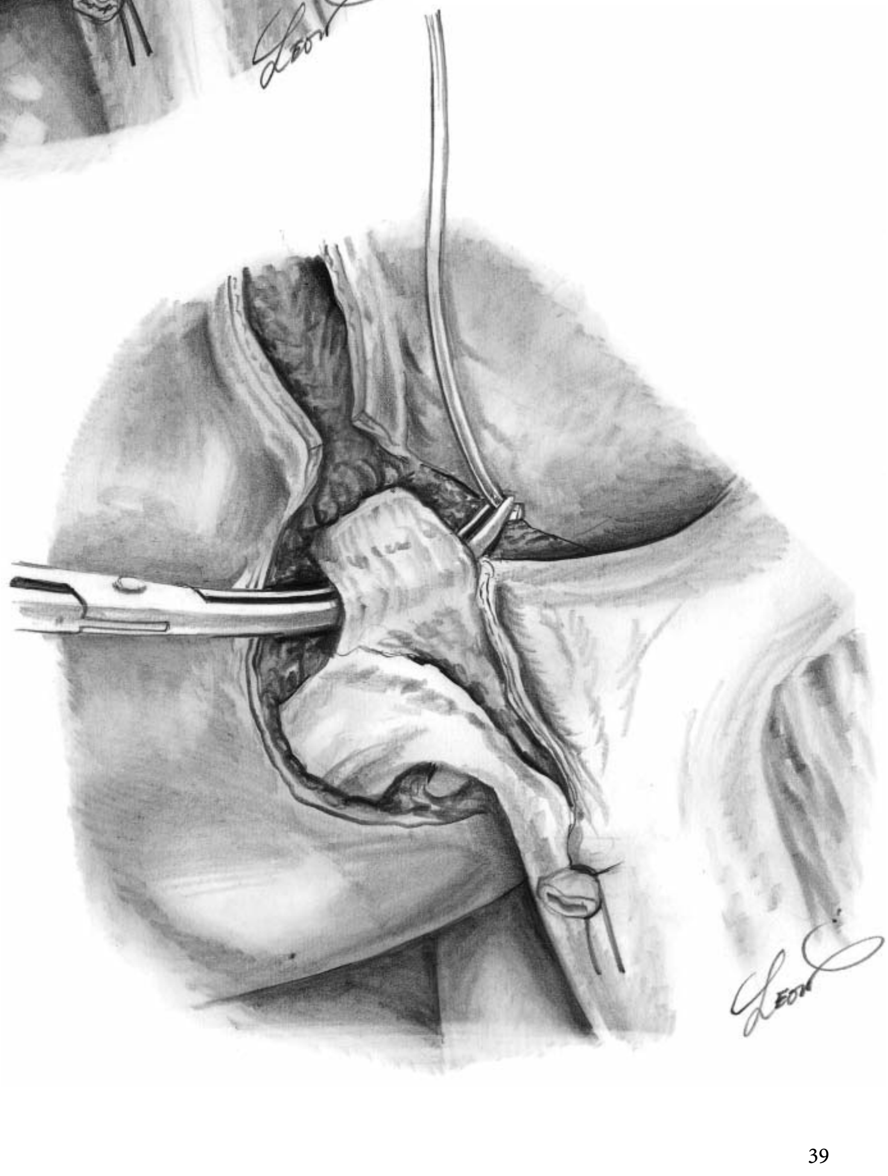


Fig. 5.13. Introduction of tape around middle segmental branch

Then (see Figs. 5.13, 5.14) choose one of four special forceps, each of slightly varied curvature, to introduce tape around the middle segmental branch. After clamping this branch (Fig. 5.15), the area of the middle segment can be recognized by its change of color.

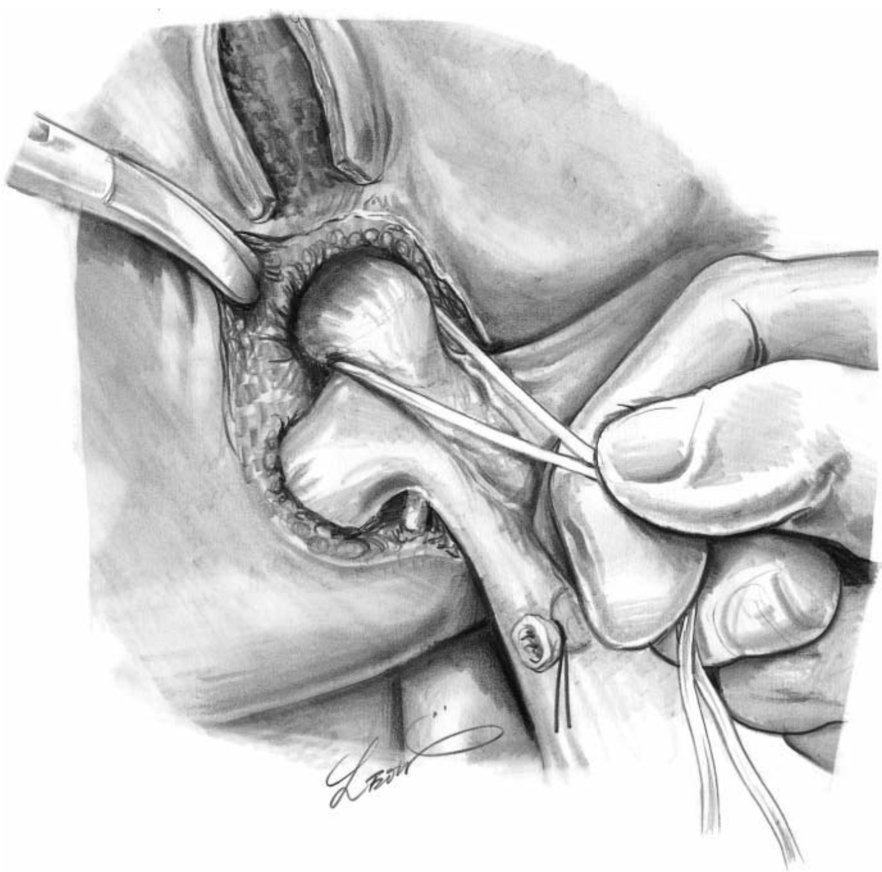


Fig. 5.14. Tape is pulled around middle segmental branch

Transection of the Middle Segmental Branch (Figs. 5.15, 5.16)

Ligate the middle segmental branch as one bundle in one ligation. In this procedure it is necessary to pull the tape (which is around the middle segmental branch), towards the operator and then ligate the middle segmental branch as close to the liver side as possible, lest the right segmental branch be damaged.

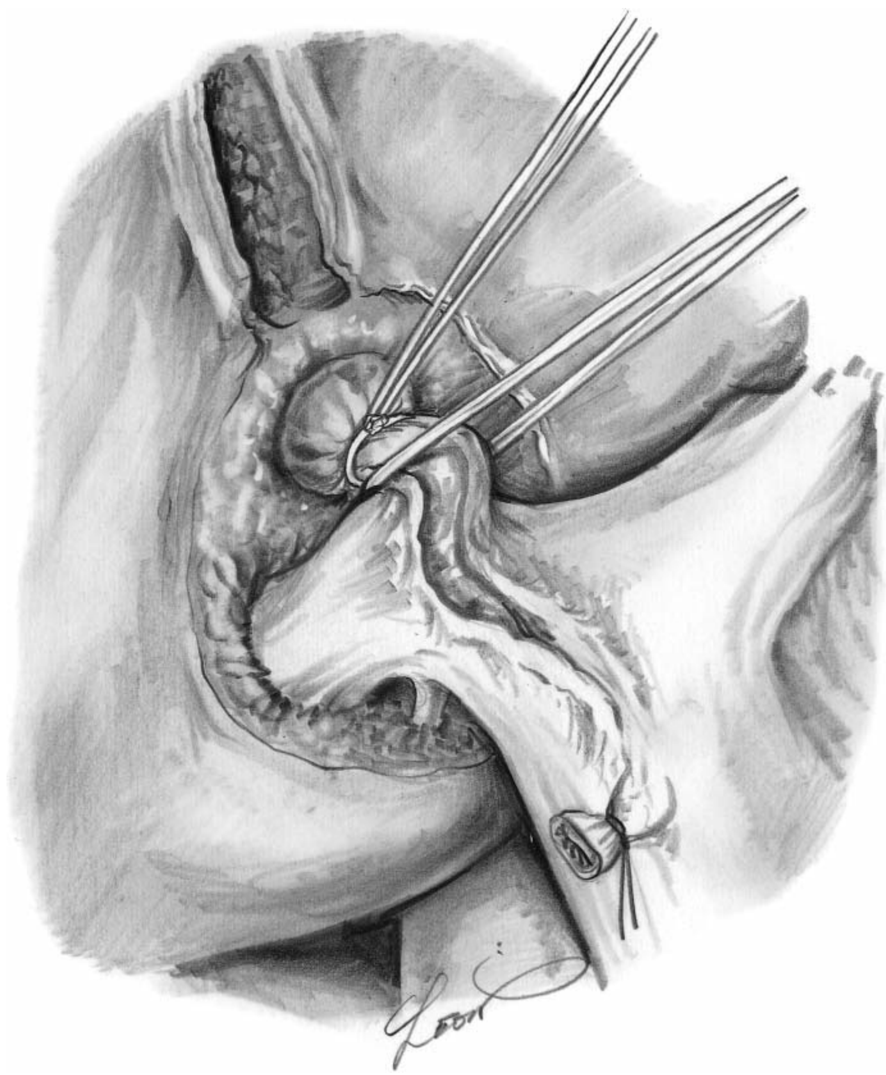


Fig. 5.15. Middle segmental branch is ligated

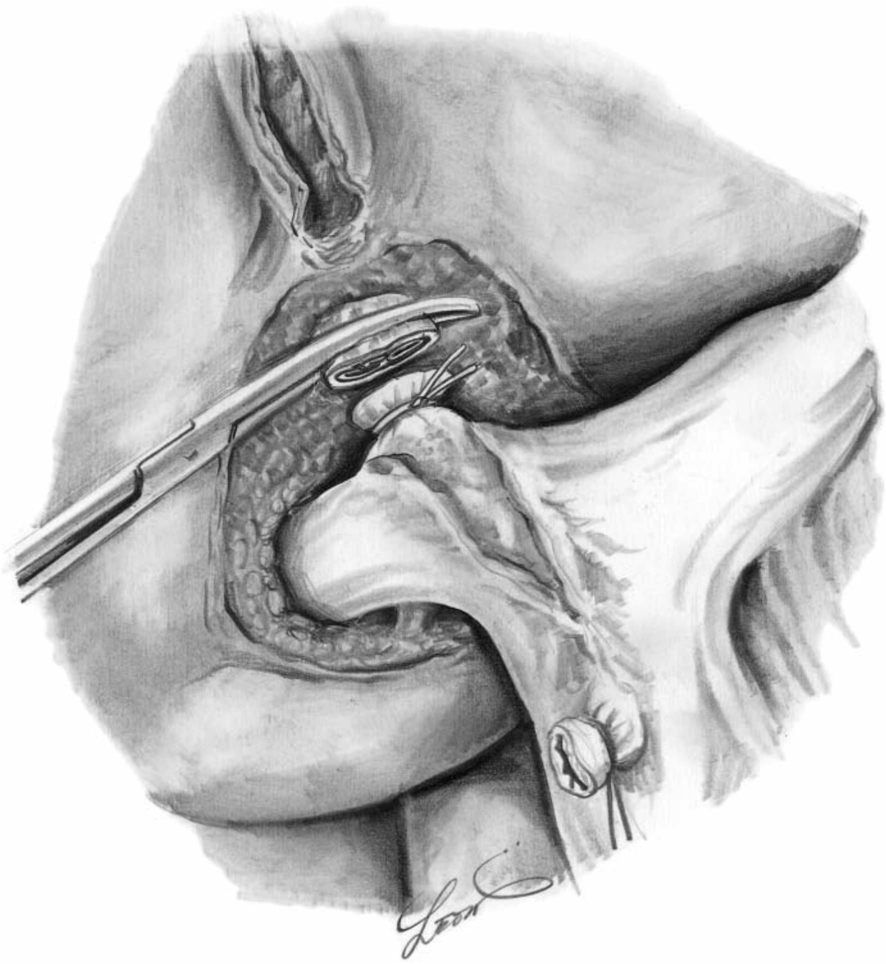


Fig. 5.16. Transection of middle segmental branch

Dissection of the Liver Parenchyma

There are two margins of the area which are demarcated for dissection, one between the left and middle segment and one between the middle and right segment. Dissection should be done on both demarcated margin lines. During the dissection of the liver parenchyma, bleeding should be controlled by the Pringle maneuver, and by IVC clamping.

While these margins are cut, the middle hepatic vein and the right hepatic vein should be intact on their remaining sides. Next, the dissection proceeds into the liver until the imaginary line AB (see Fig. 2.5) is reached.

During the dissection of the liver parenchyma, there are no small branches of the Glissonean pedicle, but only branches of the hepatic vein across the cut surface (Figs. 5.17 to 5.19).

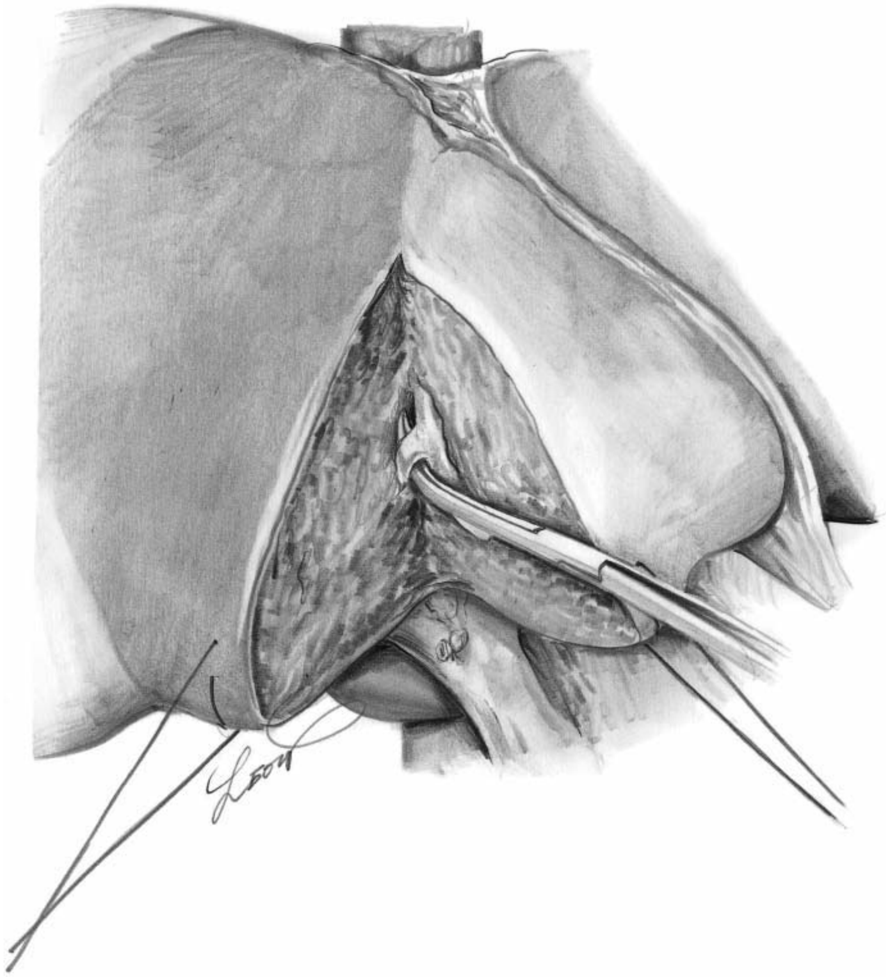


Fig. 5.17. Dissection of liver parenchyma, showing some branches of middle hepatic vein are cut

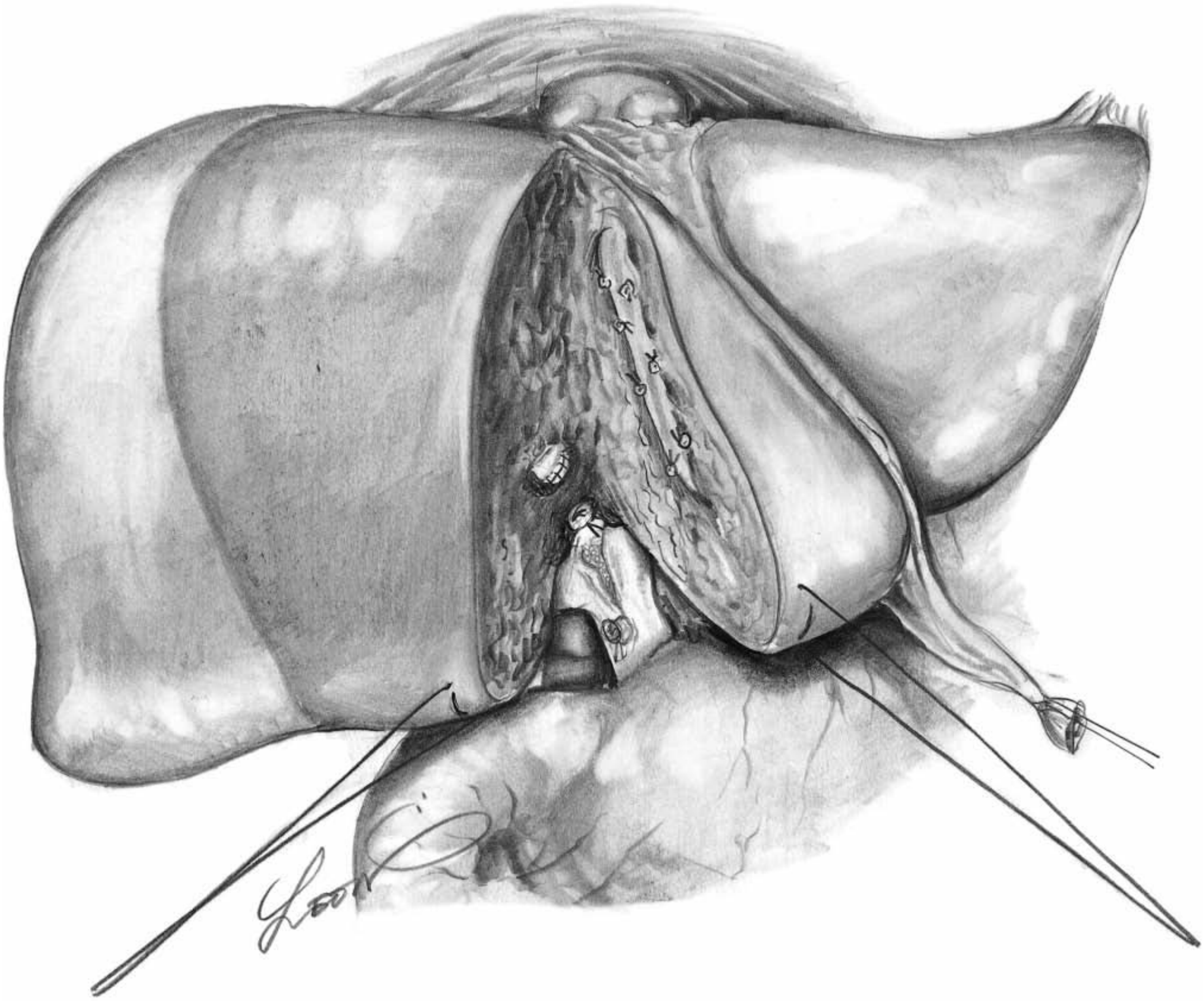


Fig. 5.18. Dissection of liver parenchyma, showing trunk of middle hepatic vein is just on the cut surface of remaining liver

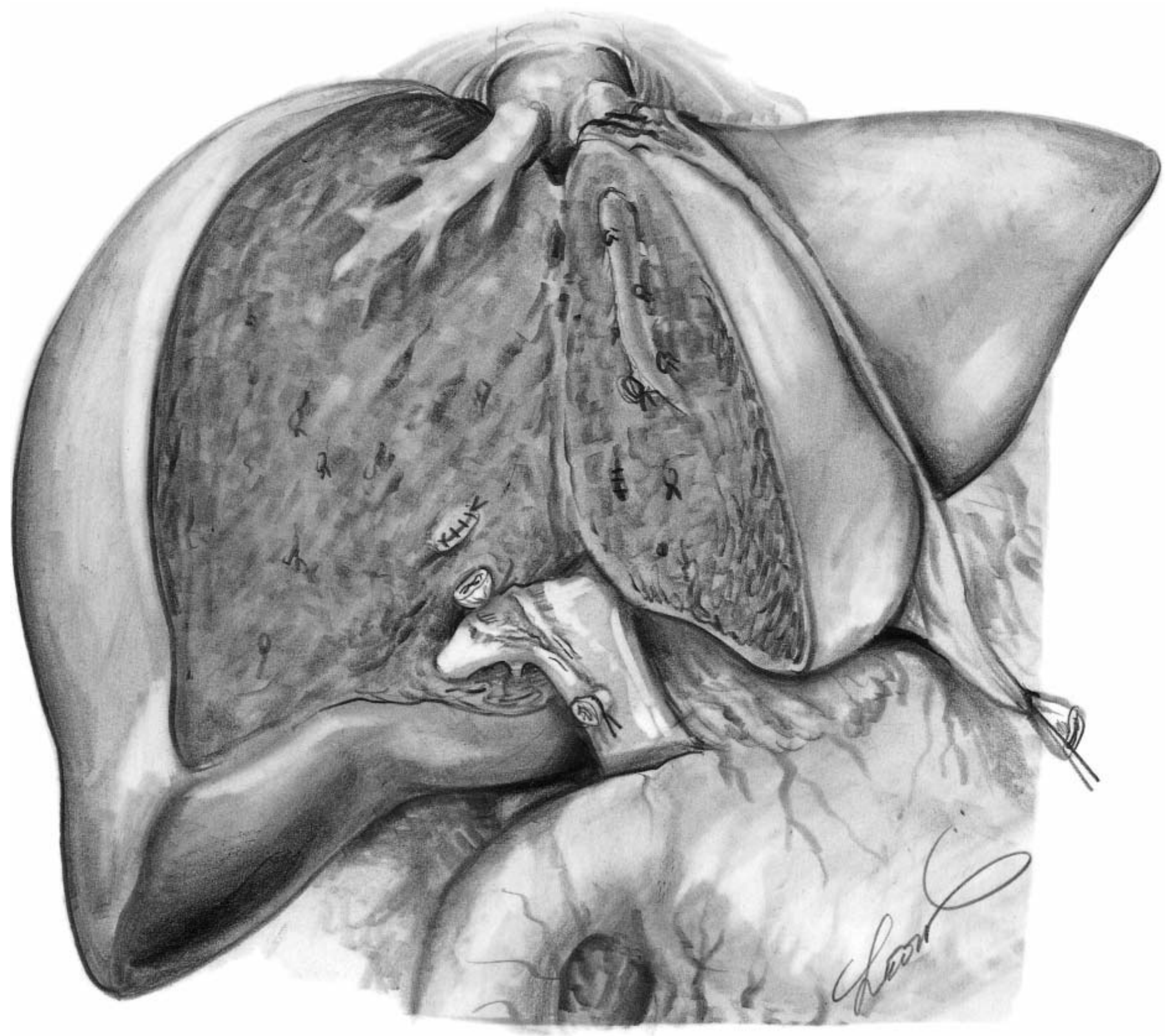


Fig. 5.19. Dissection of liver parenchyma is done by anterior approach method. Middle hepatic vein and right hepatic vein are seen on both cut surfaces

Selective Clamping of Segmental Branches (Figs. 5.20 to 5.23)

In patients with severe liver cirrhosis, alternate selective clamping of the segmental branches must be done during the dissection, to reduce liver damage and prevent congestion of the portal system. During the dissection between the middle and left segments, the left segmental branch of the Glissonean pedicle must be temporarily clamped, instead of using the Pringle maneuver. Likewise, at the time of dissection on the intersegmental plane between the middle and right segments, the right segmental branch must be clamped. In right segment or left segment resection, this selective clamping of the neighboring branch may be beneficial (Fig. 5.24).

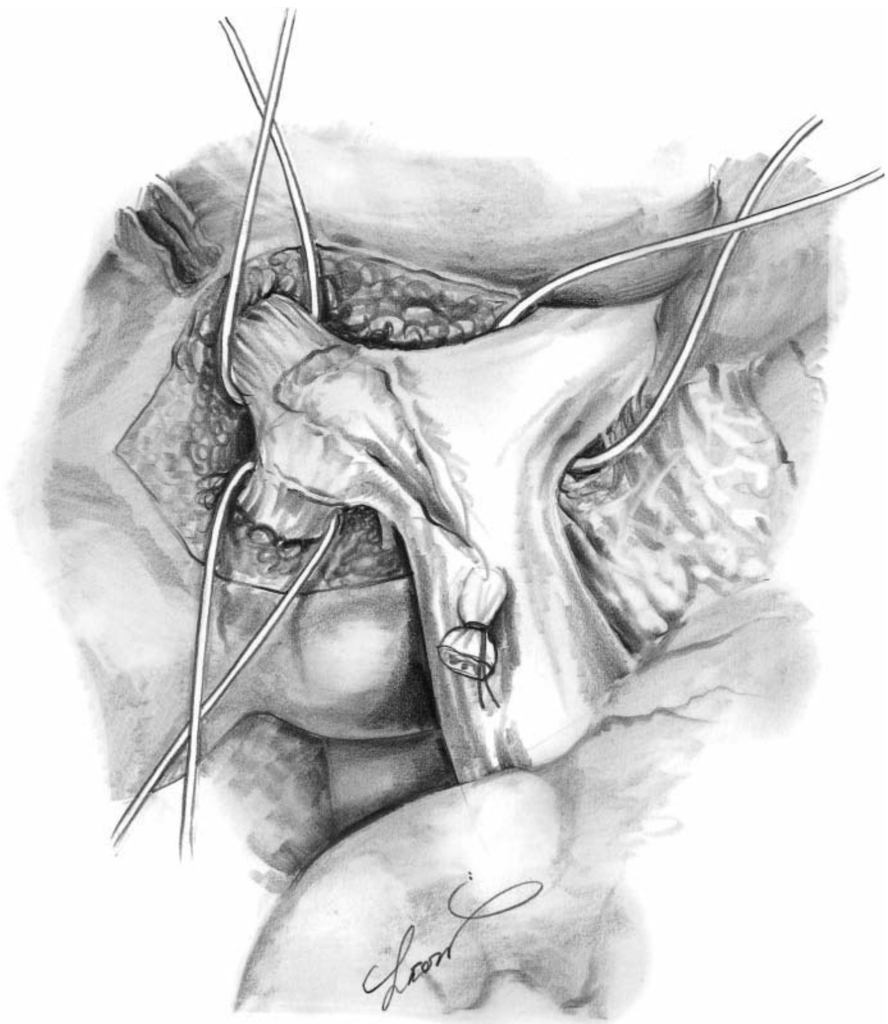


Fig. 5.20. Selective clamping of segmental branches, showing those segmental Glissonean pedicles are taped as a first step

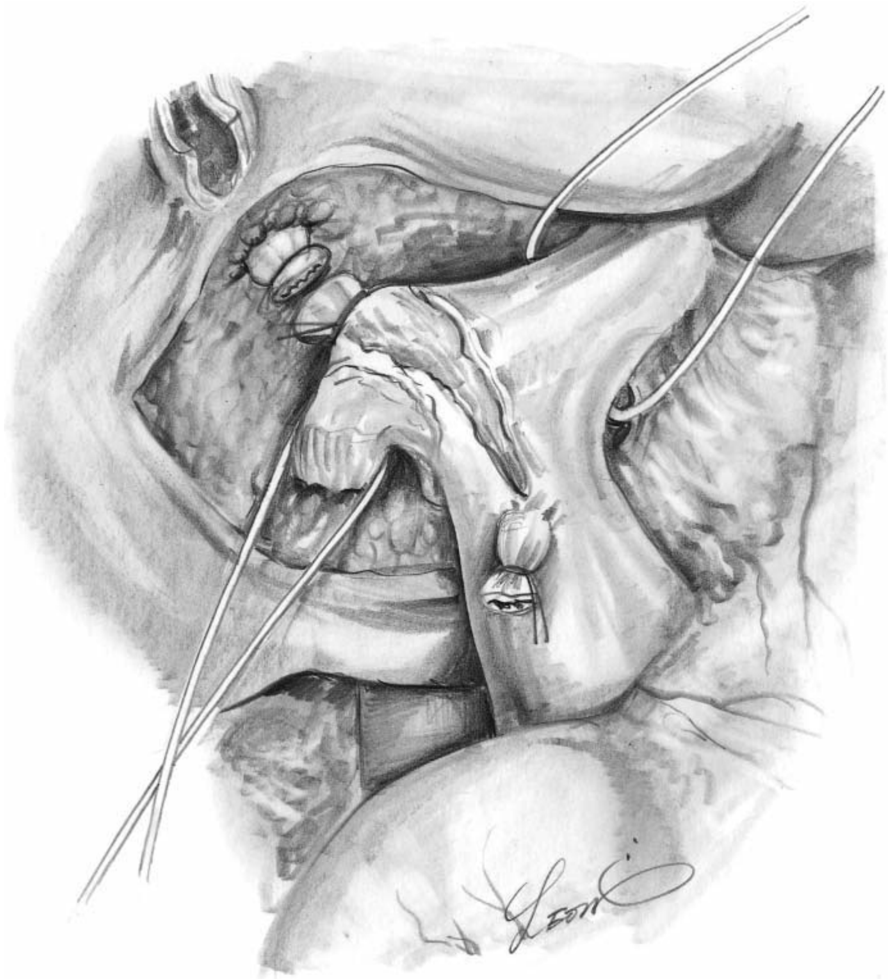


Fig. 5.21. Middle segmental branch is transected

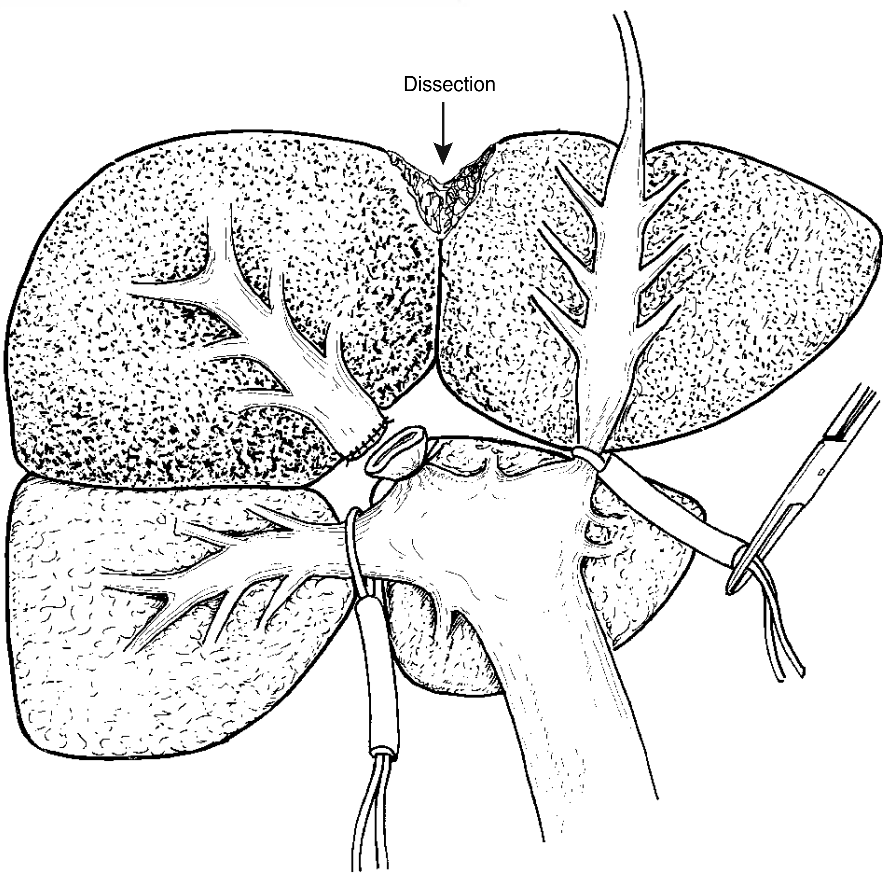


Fig. 5.22. Schema of selective clamping of segmental branches. During the dissection on intersegmental plane between left segment and middle segment, left segmental branch is clamped

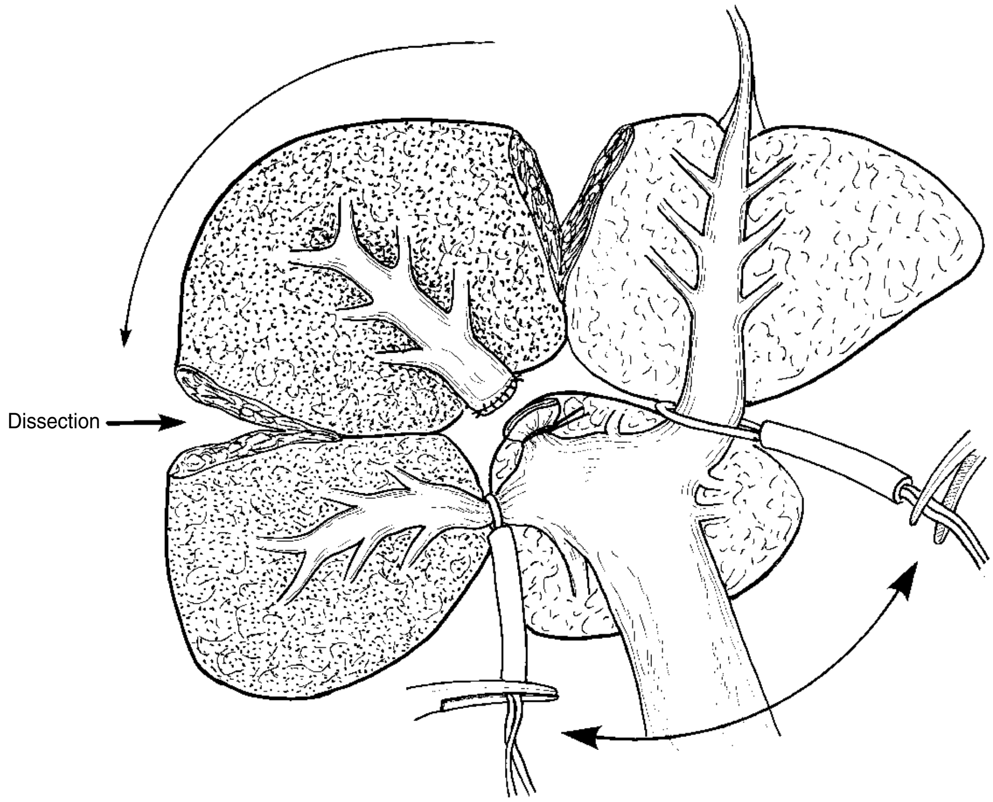


Fig. 5.23. Schema of selective clamping of segmental branches. After 15 minutes, the clamp on right segmental branch is changed, and dissection of liver is done on the intersegmental plane between middle segment and right segment

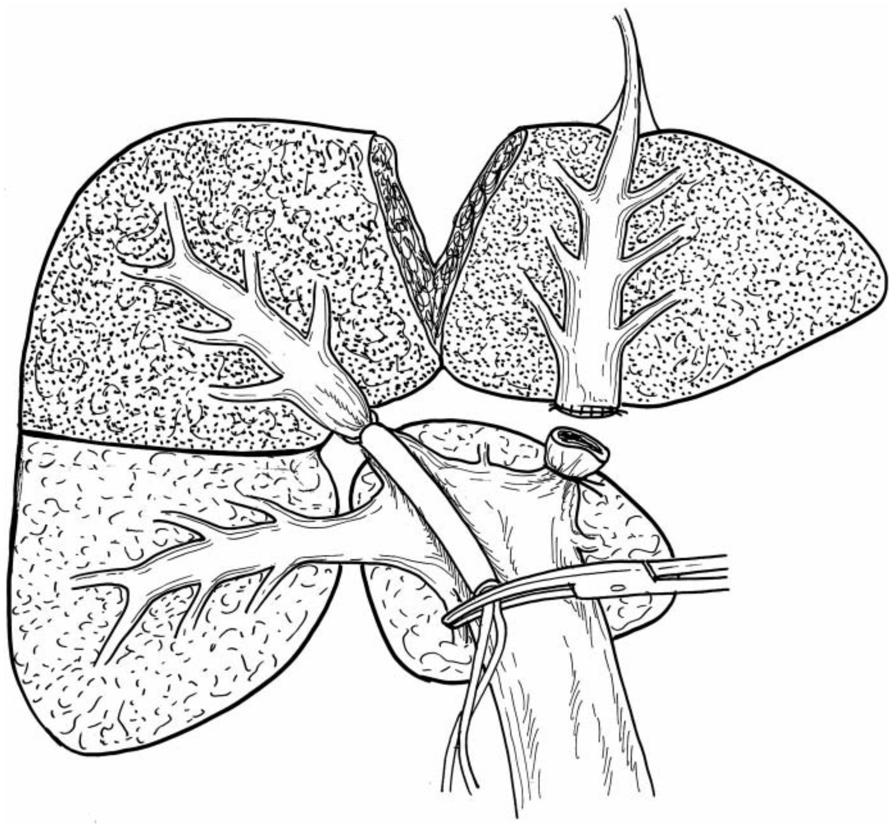


Fig. 5.24. At the time of left segmentectomy, after a left segmental branch was transected, only middle segmental branch is clamped, instead of Pringle maneuver

Resection of the Right Hepatic Segment

The right segment neighbors both the caudate area and the middle segment. The greater part of this segment is attached to the diaphragm by the right triangular ligament (bare area). This segment is nourished by one secondary branch, i.e., the right segmental branch, and is drained by the right hepatic vein and the right lower hepatic vein (Figs. 5.25 to 5.27).

Incision

Either of two kinds of incisions is suitable, the upper abdominal reverse "T" incision or a right thoracoabdominal incision.

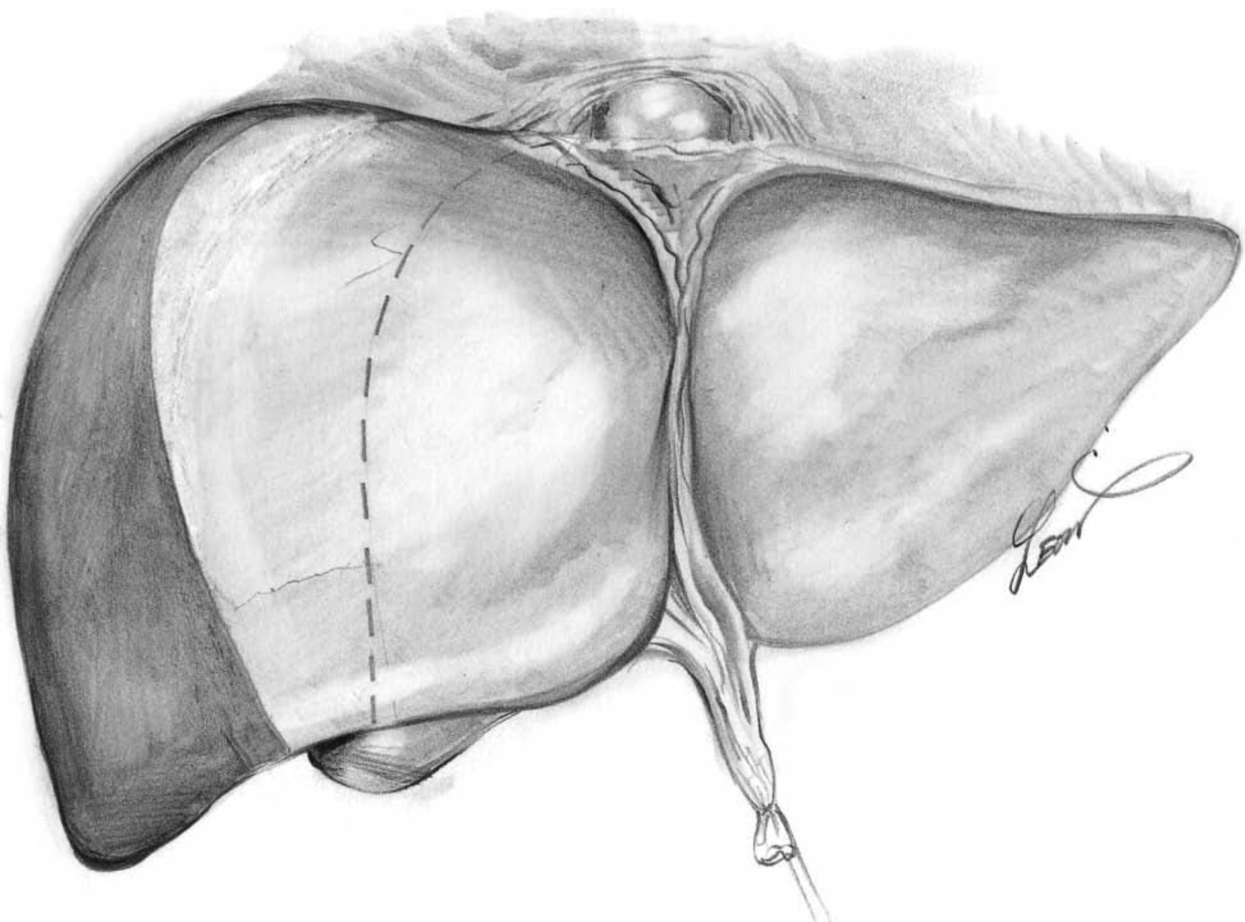


Fig. 5.25. Right hepatic segment

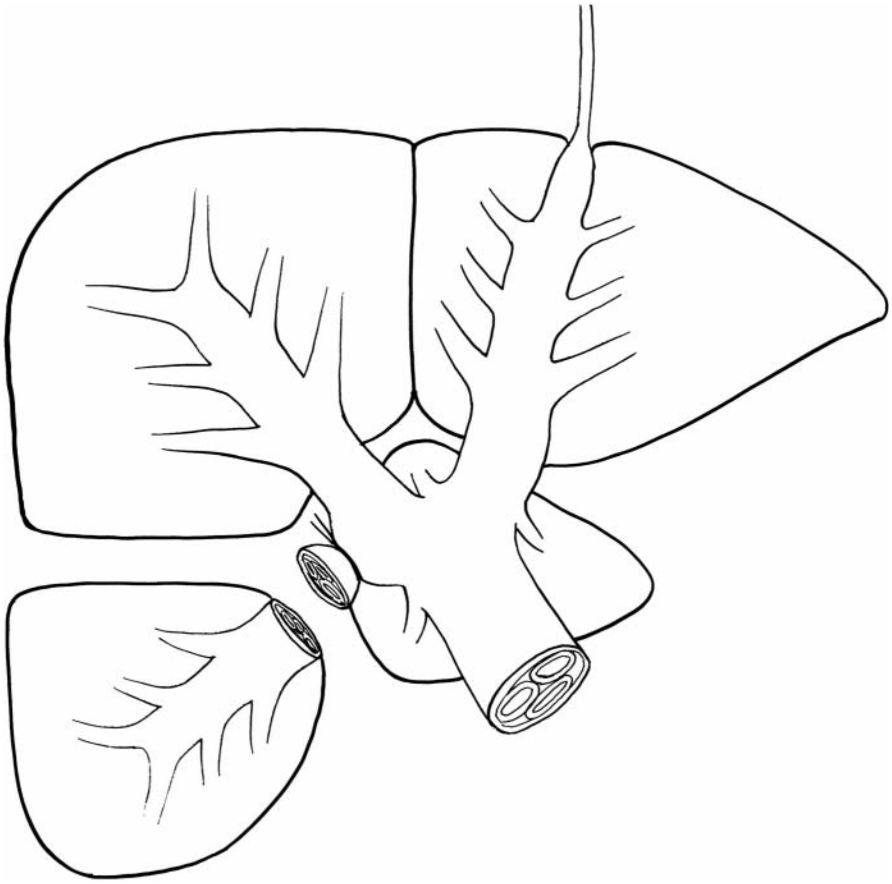


Fig. 5.26. Schema of resection of right hepatic segment. Right segmental branch of Glissonean pedicle is transected

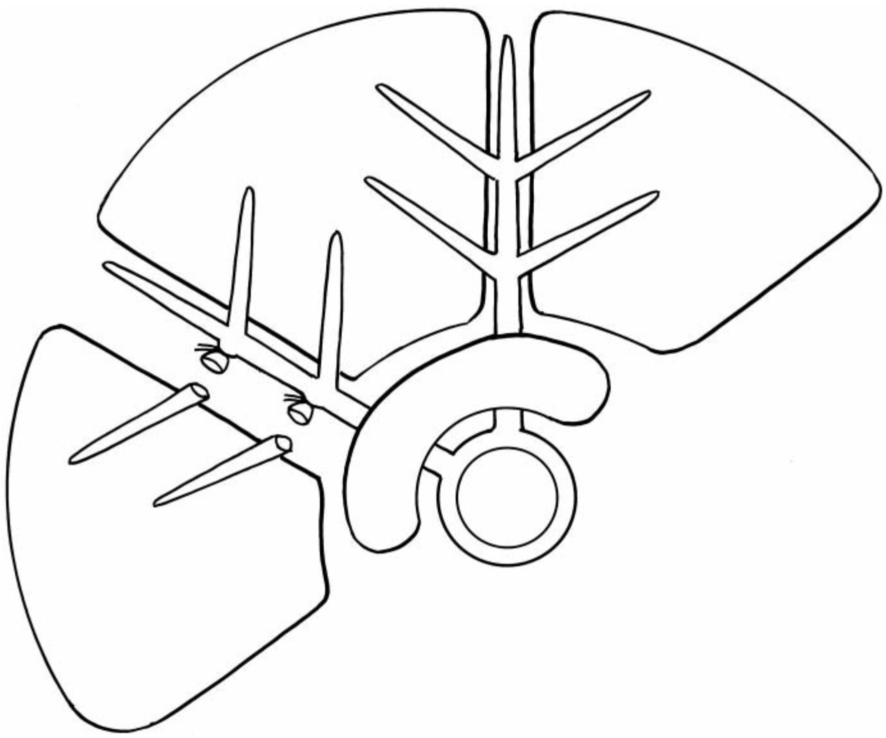


Fig. 5.27. Schema of resection of right hepatic segment. Some branches of right hepatic veins are transected

Separating the Right Segmental Branch

The right segmental branch enters the liver below the recesses just behind the cystic duct. The dissection procedure is the same as that for the middle segmental branch (Fig. 5.28). The small branches leading to the caudate area should be identified. It is essential that dissection be executed distal to these small branches. The borderline between the right lobe and the caudate area is confirmed by the sighting of the caudate process. The branches to the left of the borderline are caudate-area branches and must not be damaged. After the right segmental branch is dissected circumferentially, it is taped (Figs. 5.29, 5.30). Then the right segmental branch is ligated and transected.

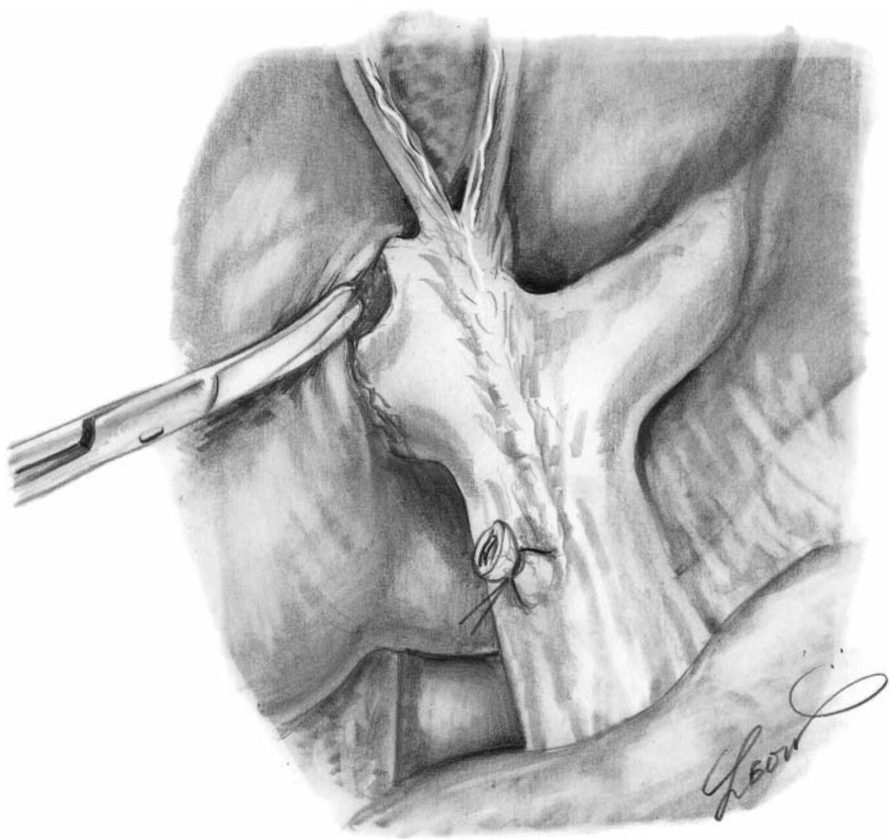
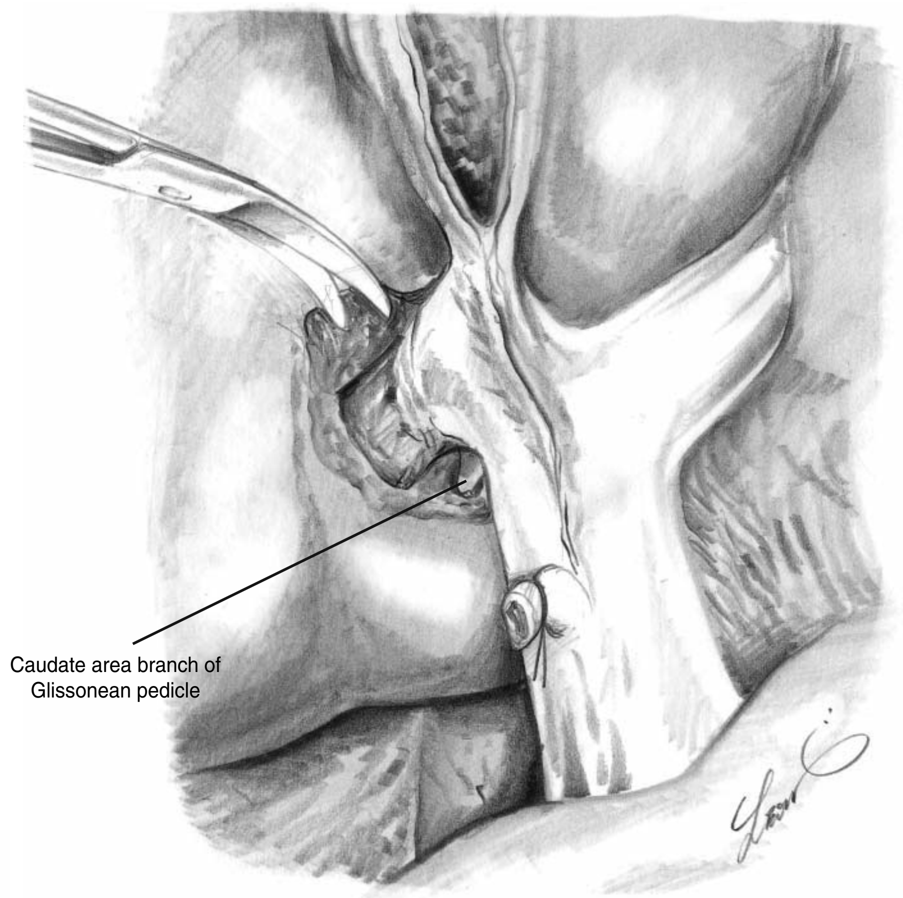


Fig. 5.28. Dissection of right segmental branch

Fig. 5.29. Circumferential dissection of right segmental branch



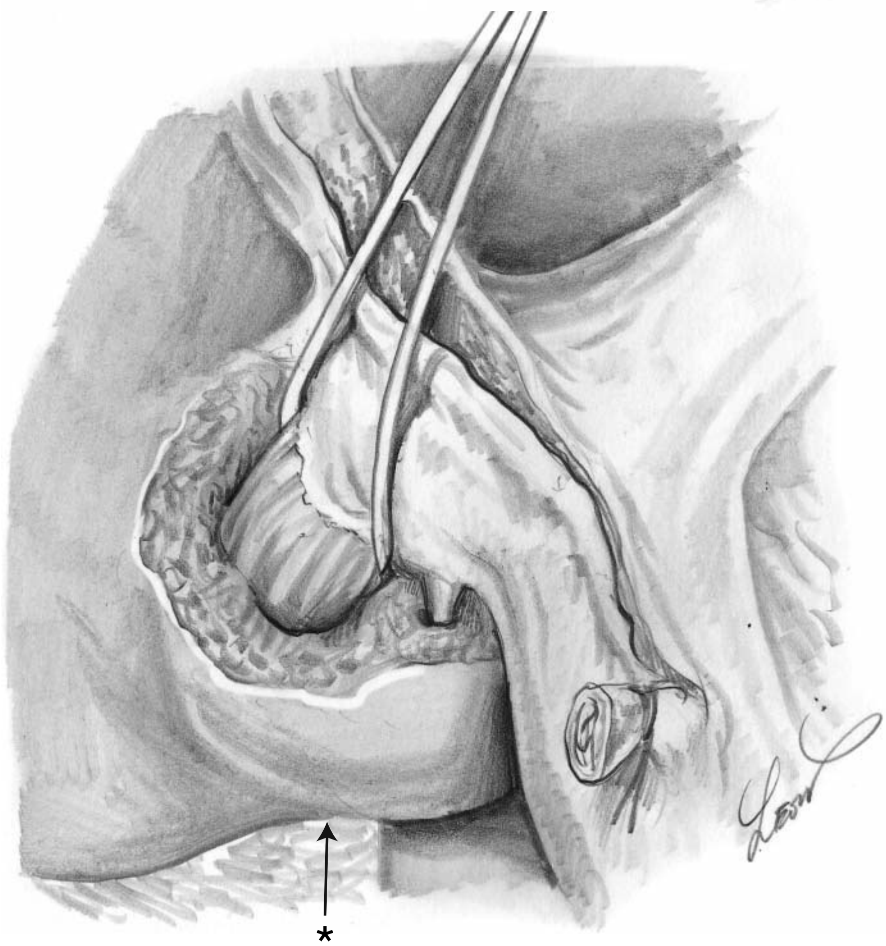


Fig. 5.30. After circumferential dissection of right segmental branch was done, this branch is taped. *Asterisk* shows the margin of caudate area

Dissection of the Liver Parenchyma (Figs. 5.31 and 5.32)

Starting at the demarcated line, make a cut along the plane formed by this line and the point that is the cut stump of the right segmental branch. It is extremely important to visualize the correct plane along which to cut. If the dissection is done just on the intersegmental plane, there will be no branches of the Glissonean pedicle, but only branches of the hepatic veins.

While the liver parenchyma is being cut, the main branch of the right hepatic vein appears, and it should be left intact. Continue the dissection along this hepatic vein, cutting only small hepatic veins coming from the right hepatic segments.

Dissection on the border between the right segment and the caudate area must be done on the paracaval triangle.

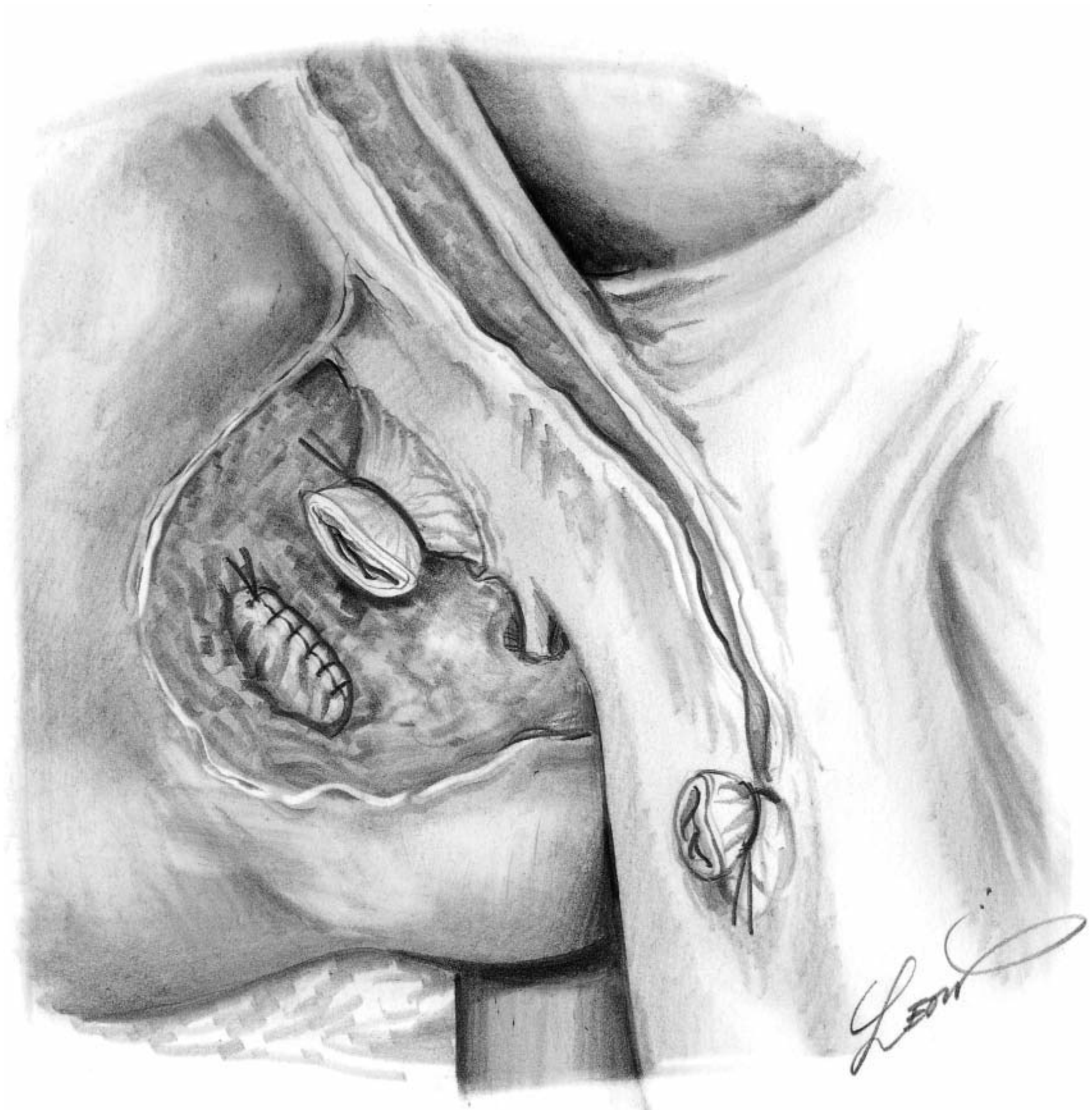


Fig. 5.31. Transection of right segmental branch

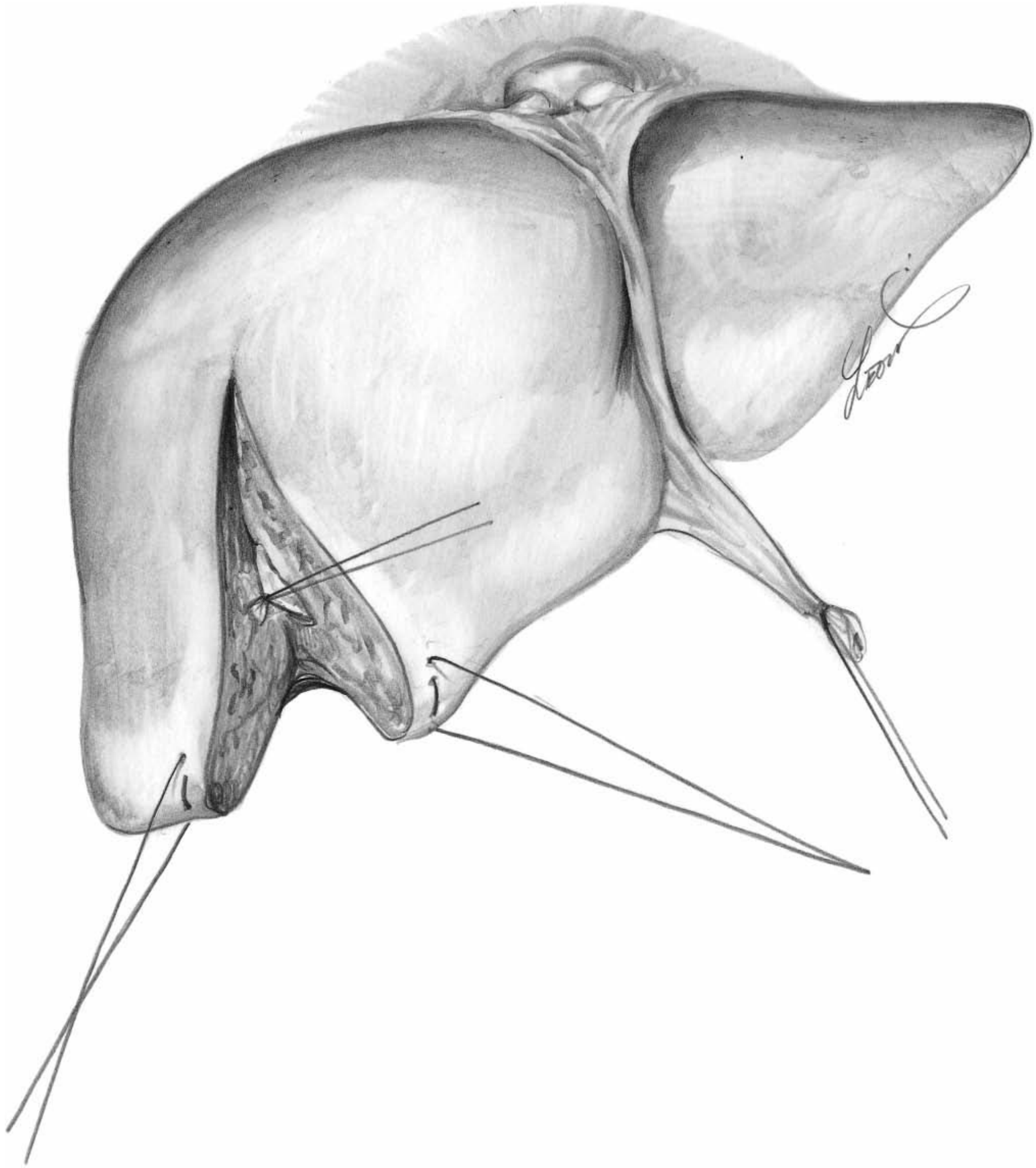


Fig. 5.32. Dissection of liver parenchyma. Some branches of right hepatic vein are transected. Main trunk of right hepatic vein should be left intact

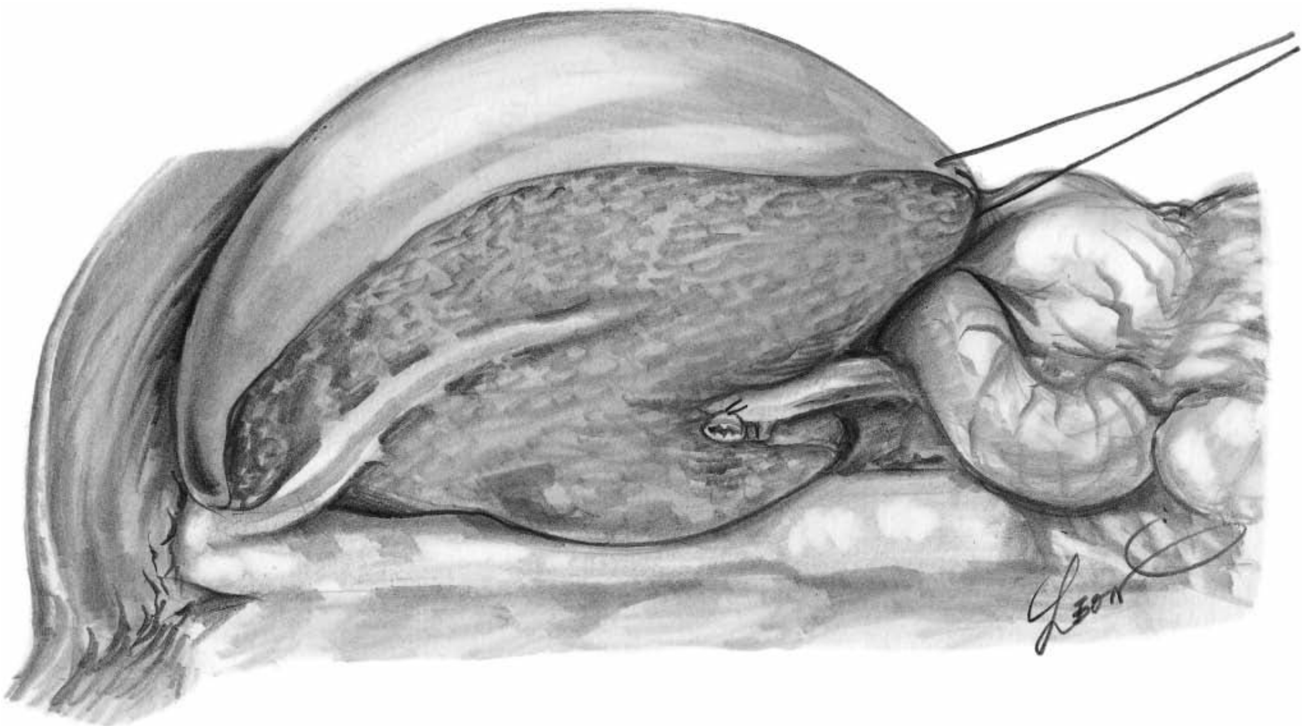


Fig. 5.33. Dissection of liver parenchyma, showing main trunk of right hepatic vein just on the cut surface

How to Tape the Whole Right Segmental Branch

In some individuals, the right segmental branch bifurcates just at its origin into tertiary branches of inferior and superior areas (Figs. 5.34, 5.35). In such individuals, it is sometimes difficult to introduce the forceps around the segmental branch for taping because it is too wide. Also, sometimes we introduce the forceps around the inferior branch only (Fig. 5.36). The superior branch sometimes cannot be seen because it lies deep in the liver.

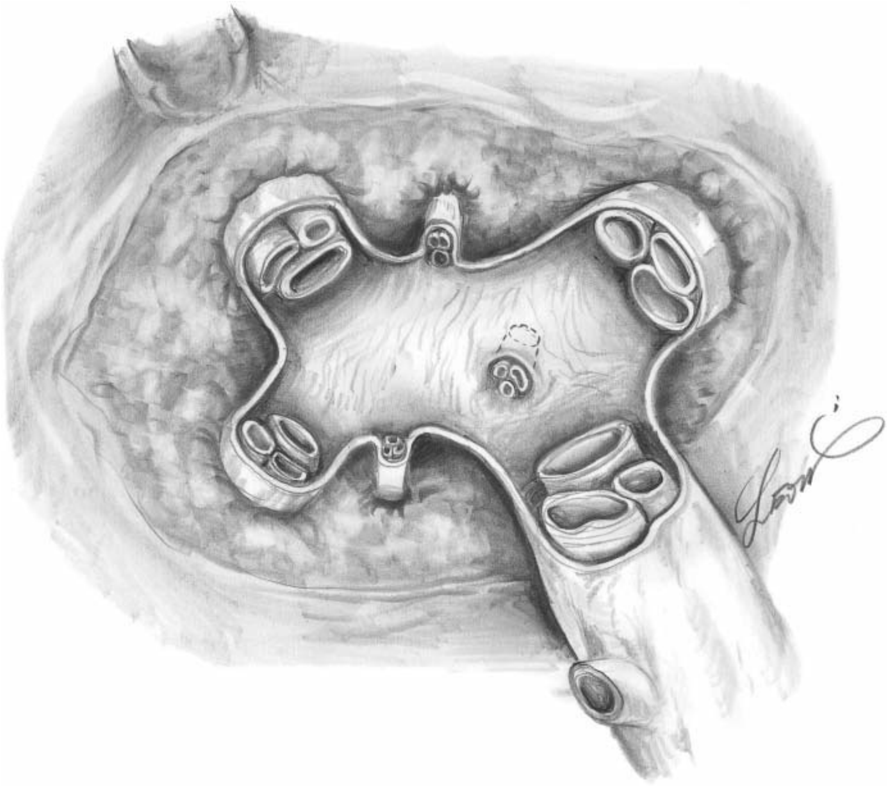


Fig. 5.34. Example of right segmental branch bifurcation at its origin, showing standard form of segmental branch approaching the liver. Three large segmental branches come into the liver

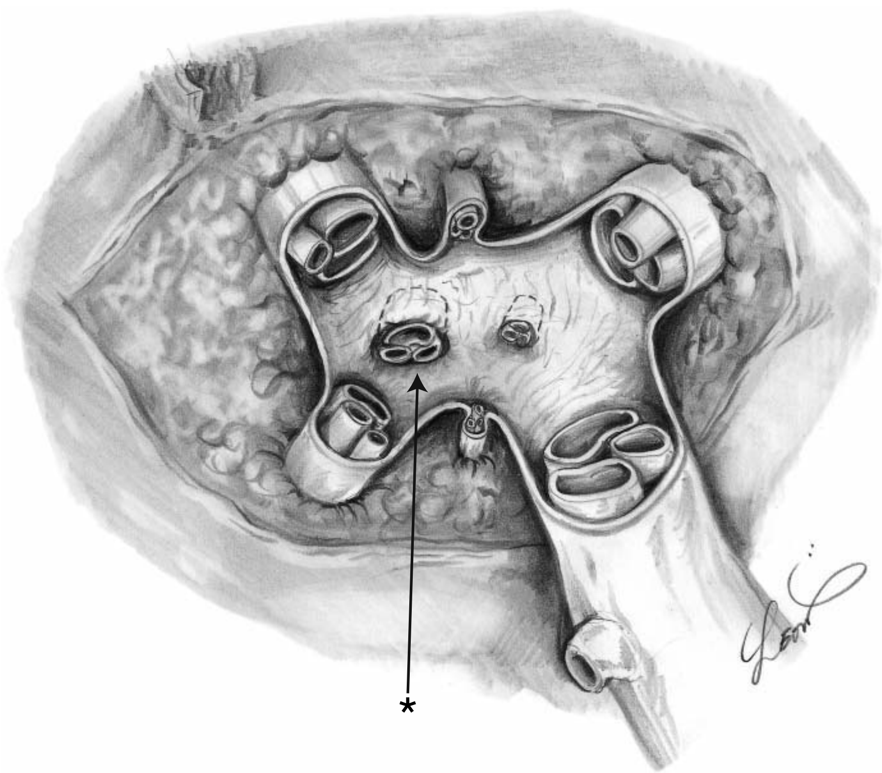


Fig. 5.35. Another type of right segmental branch bifurcation. In some cases the right segmental branch is bifurcated just at the origin of the right segmental branch. In these cases the branch (*) is hidden

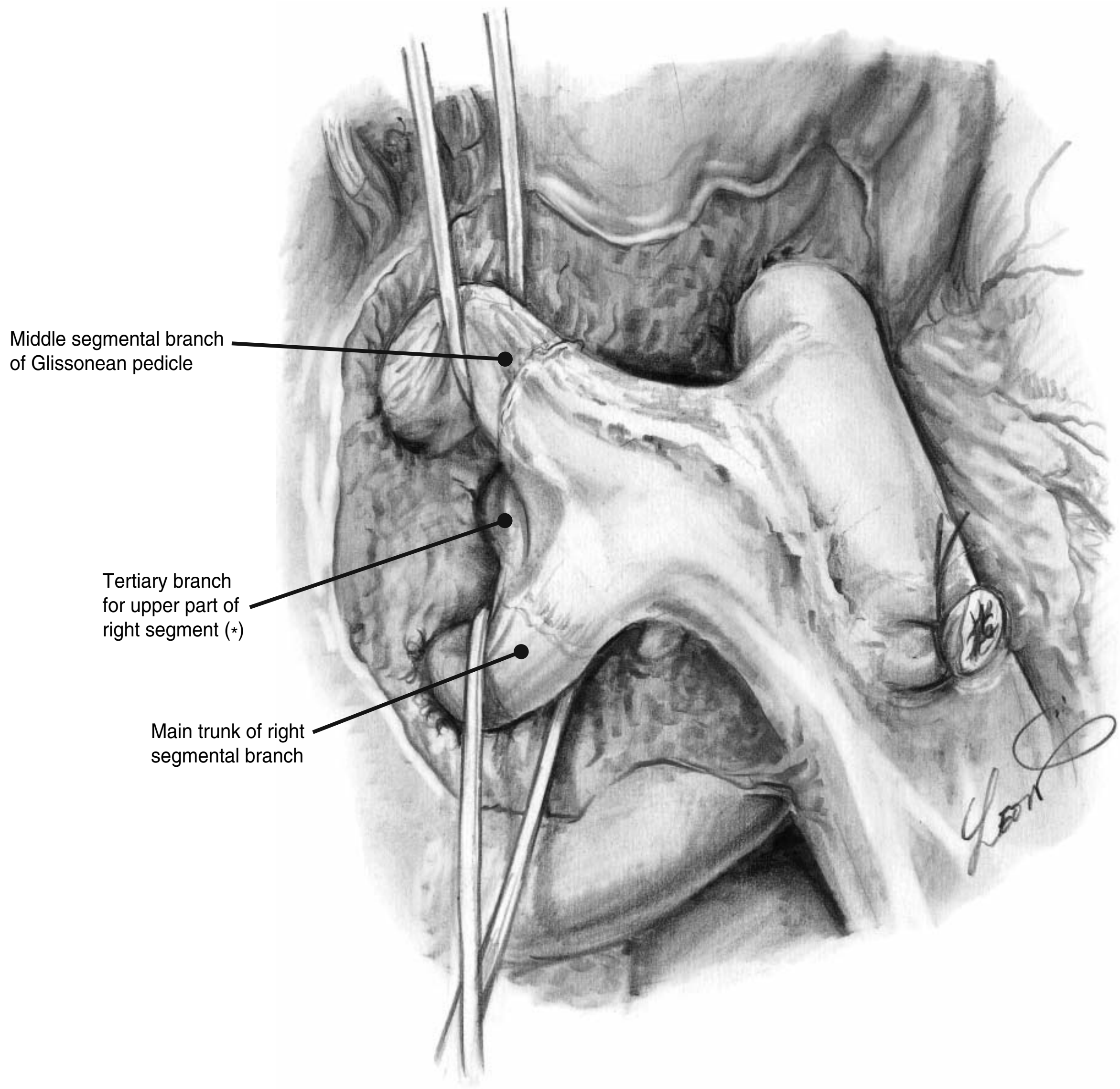
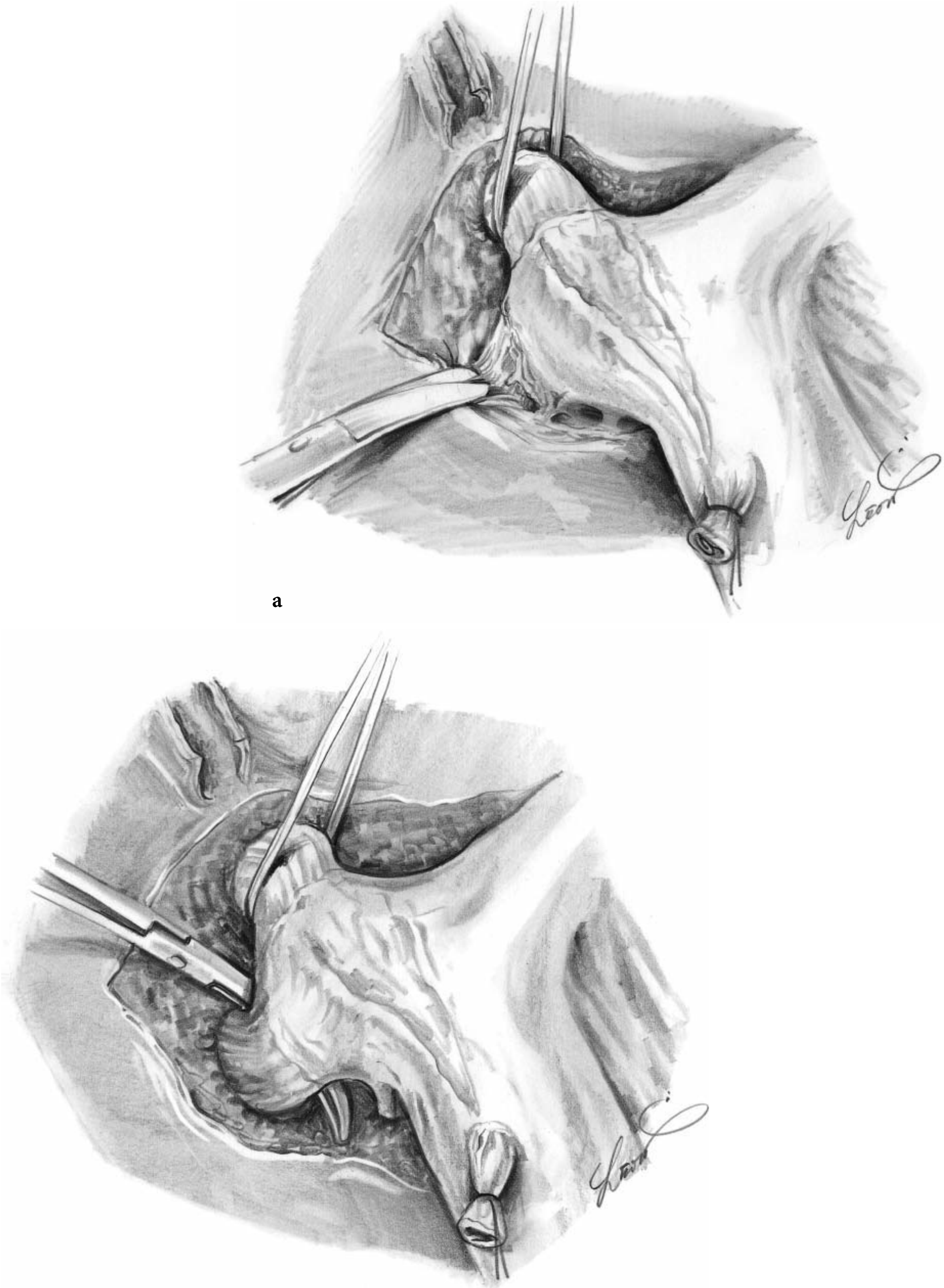


Fig. 5.36. (*) branch is hidden behind the main right segmental branch

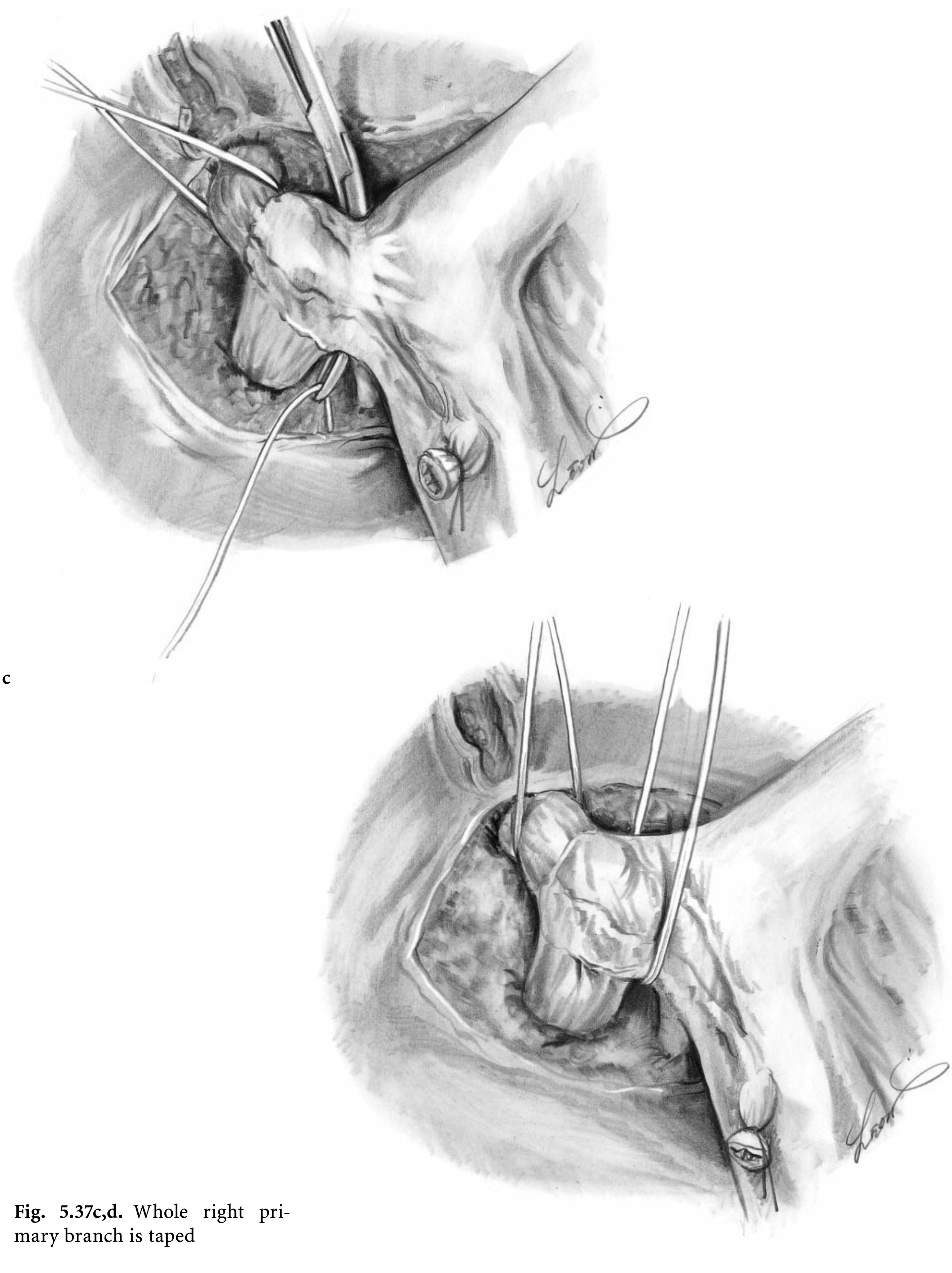
For the proficient operator, the following procedure (Fig. 5.37a–g) is recommended. First the middle segmental branch is taped. The right segmental branch is detached from the surrounding liver tissue as much as possible. The primary right branch is taped, and the end of this tape is drawn out under the middle segmental branch, resulting in the taping of the whole right segmental branch.



a

b

Fig. 5.37a–h. Taping of whole segmental branch—procedure for the proficient operator. **a** The middle segmental branch is taped as first step; **b** The right segmental branch is taped. In some cases, it is difficult to introduce forceps behind the right segmental branch, because of some resistance. Do not insert the forceps by force, and skip to next procedure

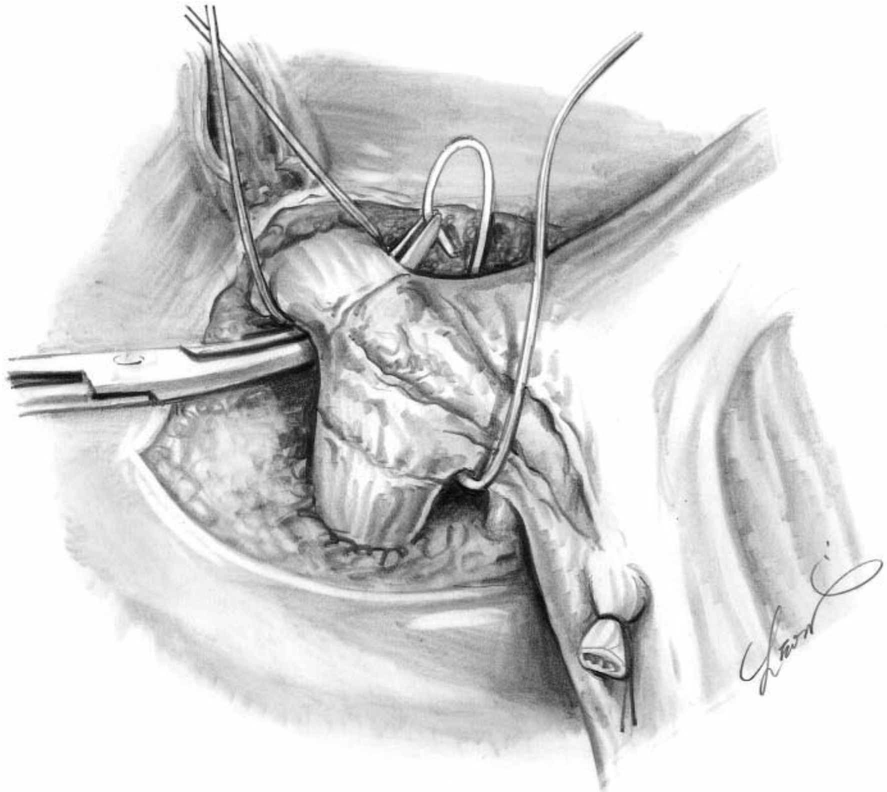


c

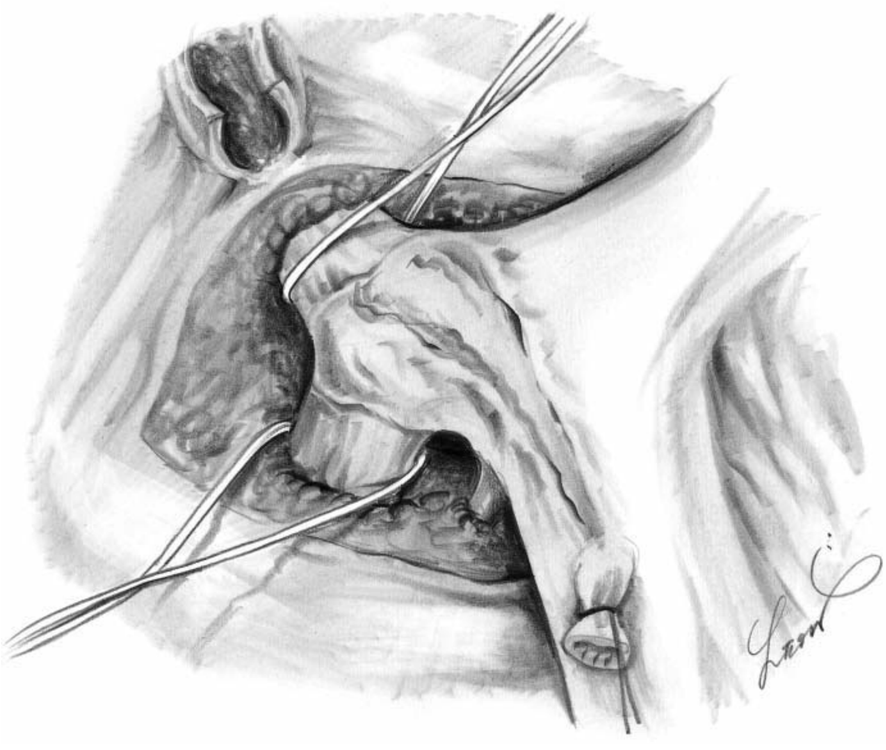
d

Fig. 5.37c,d. Whole right primary branch is taped

Fig. 5.37e. The end of this tape is drawn out under the middle segmental branch



e



f

Fig. 5.37f. The taping of whole right segmental branch is completed

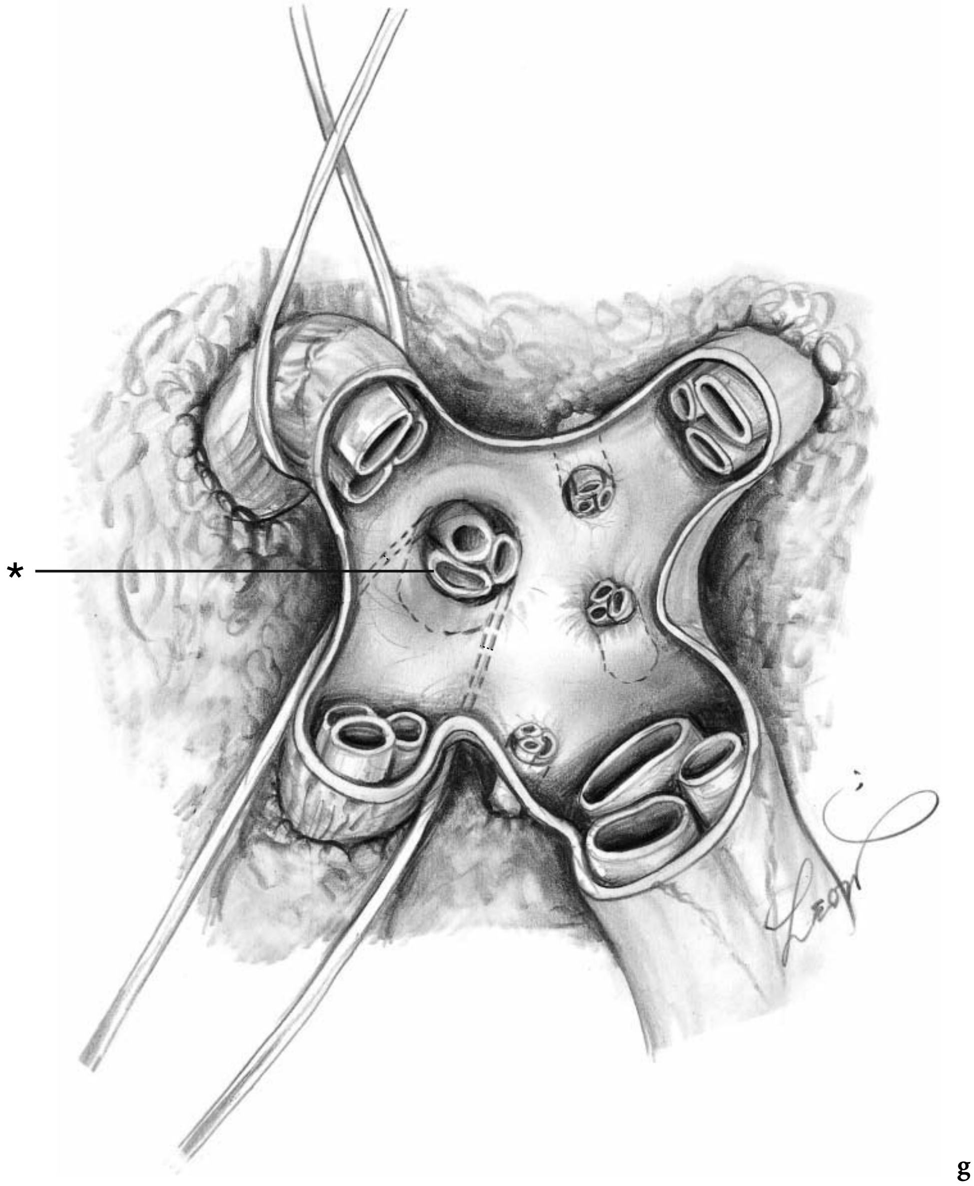


Fig. 5.37g. *This tertiary branch is also taped

Resection of the Left Hepatic Segment (See DVD 1)

This procedure is commonly called a "left lobectomy." The left hepatic segment touches the middle segment and touches the caudate area on the paracaval triangle and is fed by the left segmental branch and drained by the left and middle hepatic veins (Figs. 5.38 to 5.40).

Incision

Make an upper abdominal reverse "T" incision.

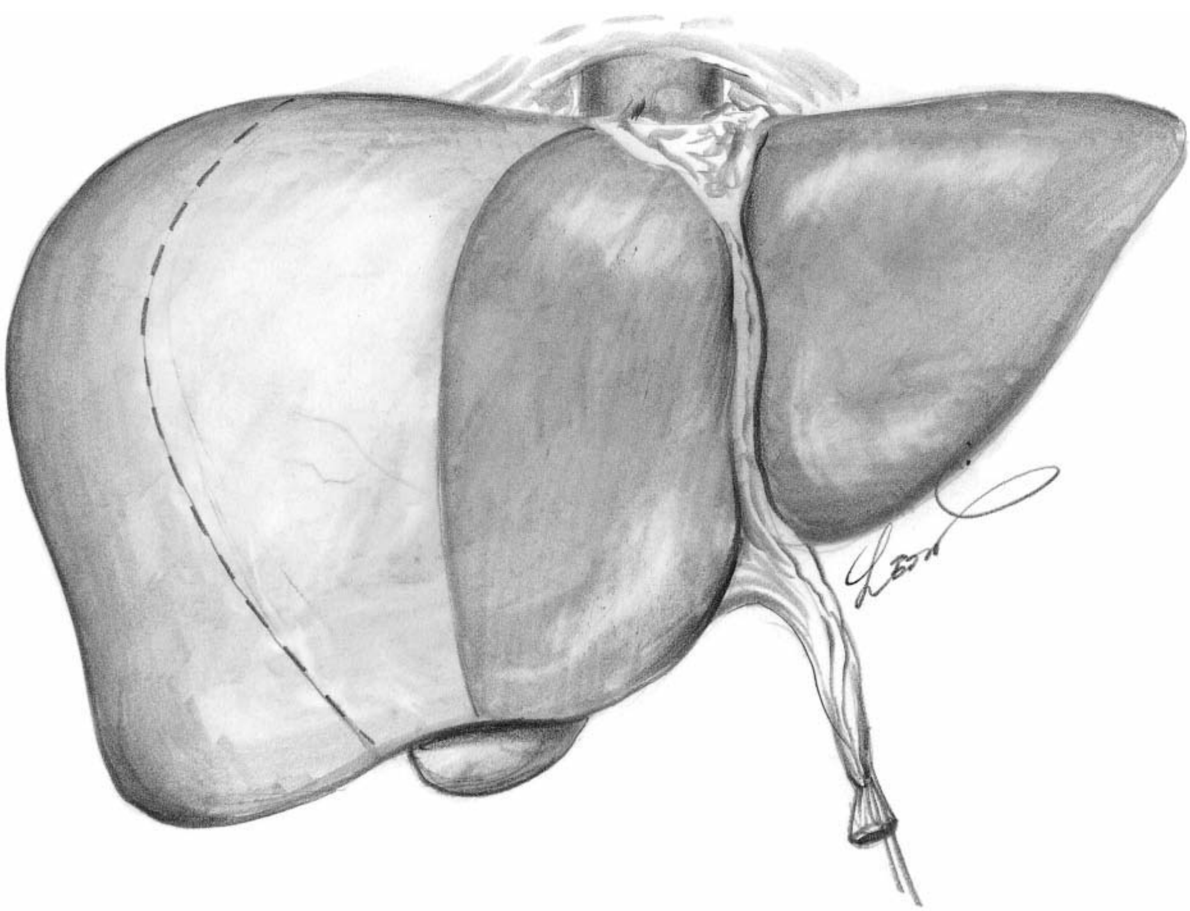


Fig. 5.38. Left hepatic segment

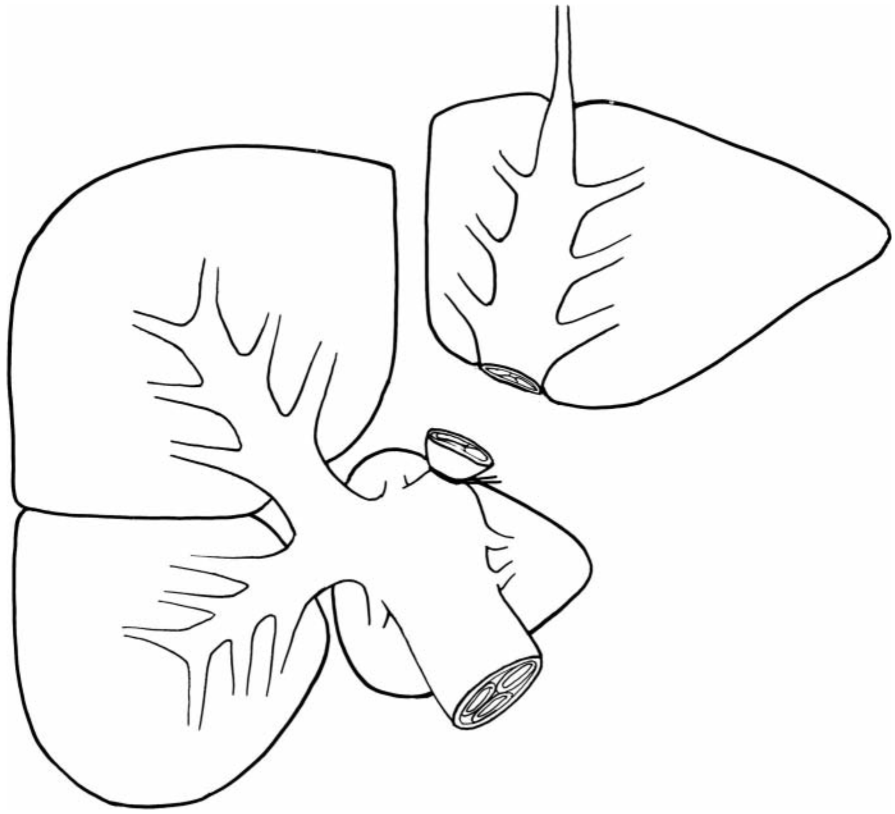


Fig. 5.39. Schema of resection of left hepatic segment. Transection of left segmental branch of Glissonean pedicle

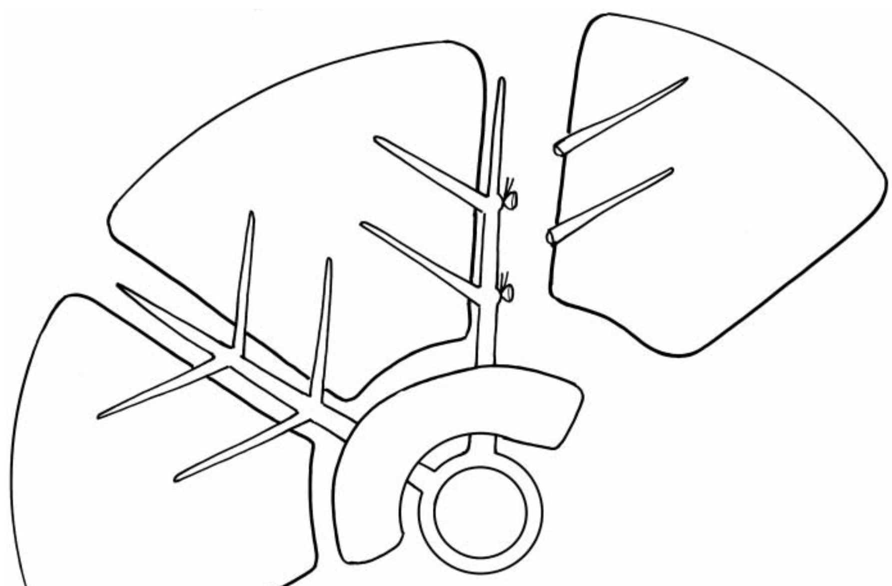


Fig. 5.40. Some hepatic vein branches are cut

Transection of the Left Segmental Branch (Fig. 5.41)

The round ligament is freed from the abdominal wall. Then the round ligament is lifted upward so that the umbilical portion can be seen en face. The umbilical portion (left segmental branch) is vertical to the flat position of the left primary branch. The separation of the right side of the left segmental

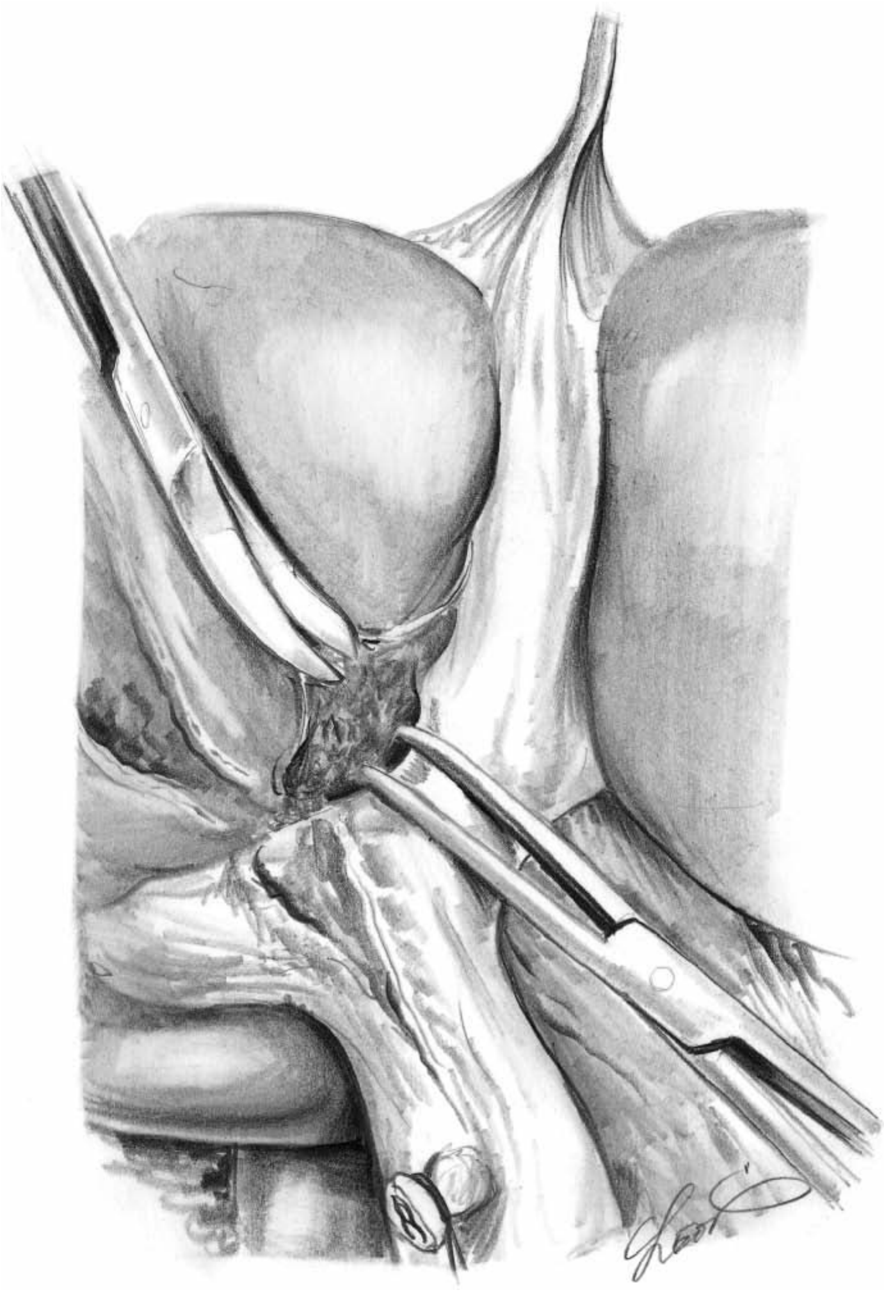


Fig. 5.41. Right side of the left segmental branch is detached from hepatic hilus

branch begins at this corner and the separation continues behind the umbilical portion.

Then (Fig. 5.42), the left lateral liver is lifted upward with forceps to be able to confirm the whole length of the duct of Arantius. The liver capsule is dissected along the frontal surface of the duct of Arantius from the cranial to the caudal aspect, reaching behind the left segmental branch. Appropriate forceps are introduced from the right side of the umbilical portion to the left side in front of the duct of Arantius (Fig. 5.43).

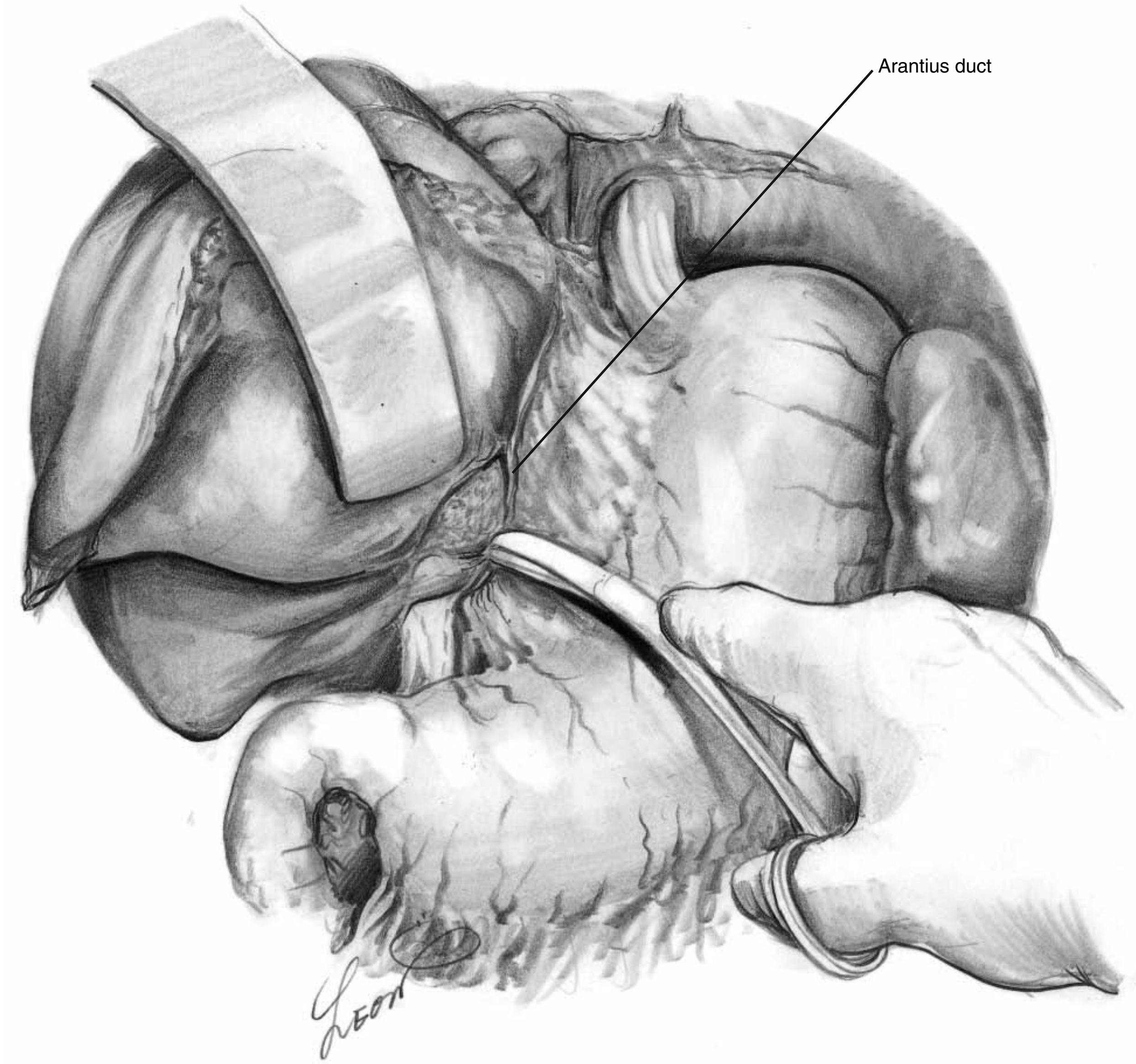


Fig. 5.42. Lifting the left lateral liver, and left side of the left segmental branch is detached on hepatic hilus. The liver capsule is dissected along the duct of Arantius

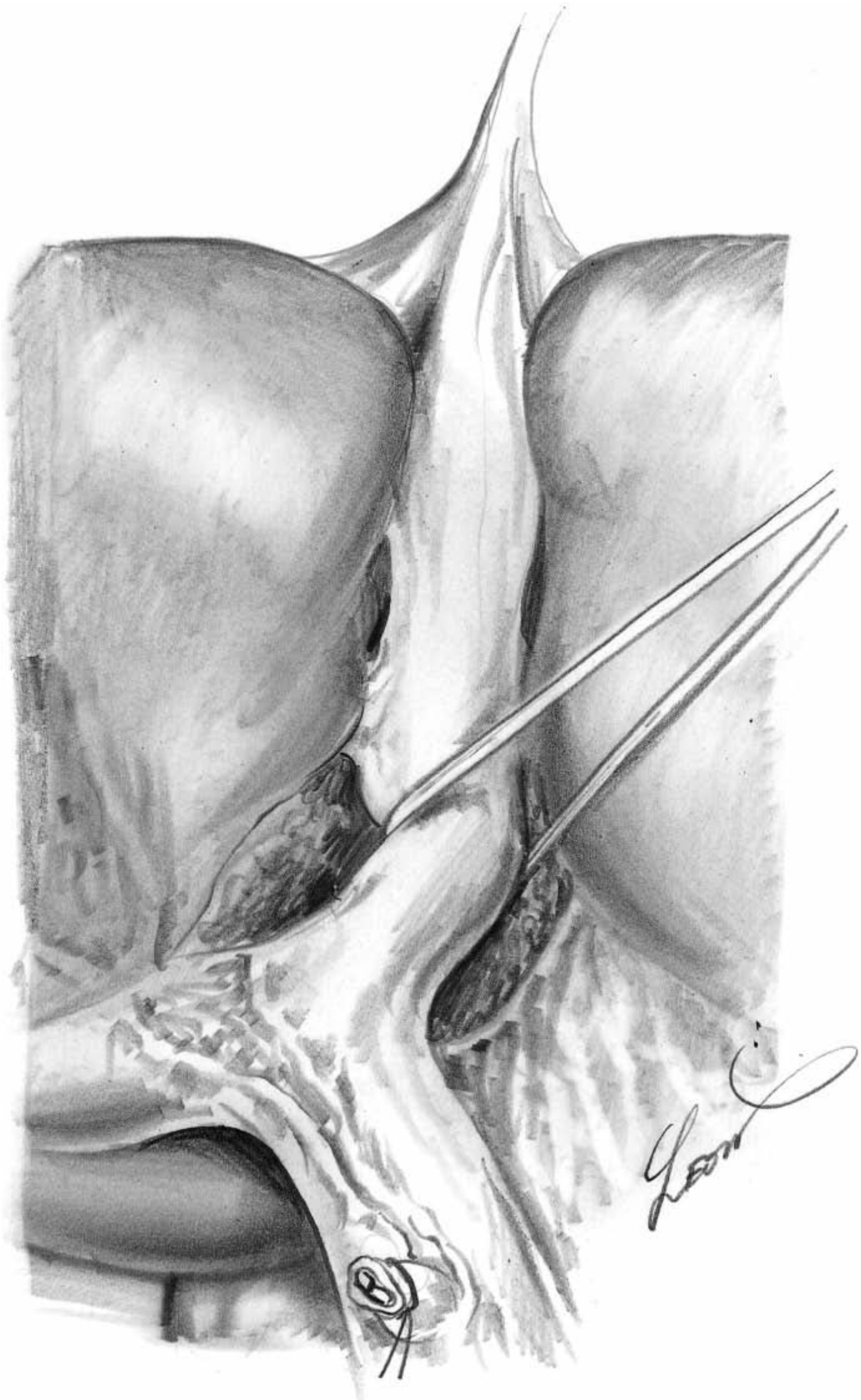


Fig. 5.43. The left segmental branch is taped at this origin

Transection of the left segmental branch is done at the level of the anterior surface of the lesser omentum (Fig. 5.44) so that any branches feeding the caudate area cannot be injured. In many individuals, the root of the left segmental branch is wide. In these patients, transection using a liner cutter is useful (Fig. 5.45a,b).

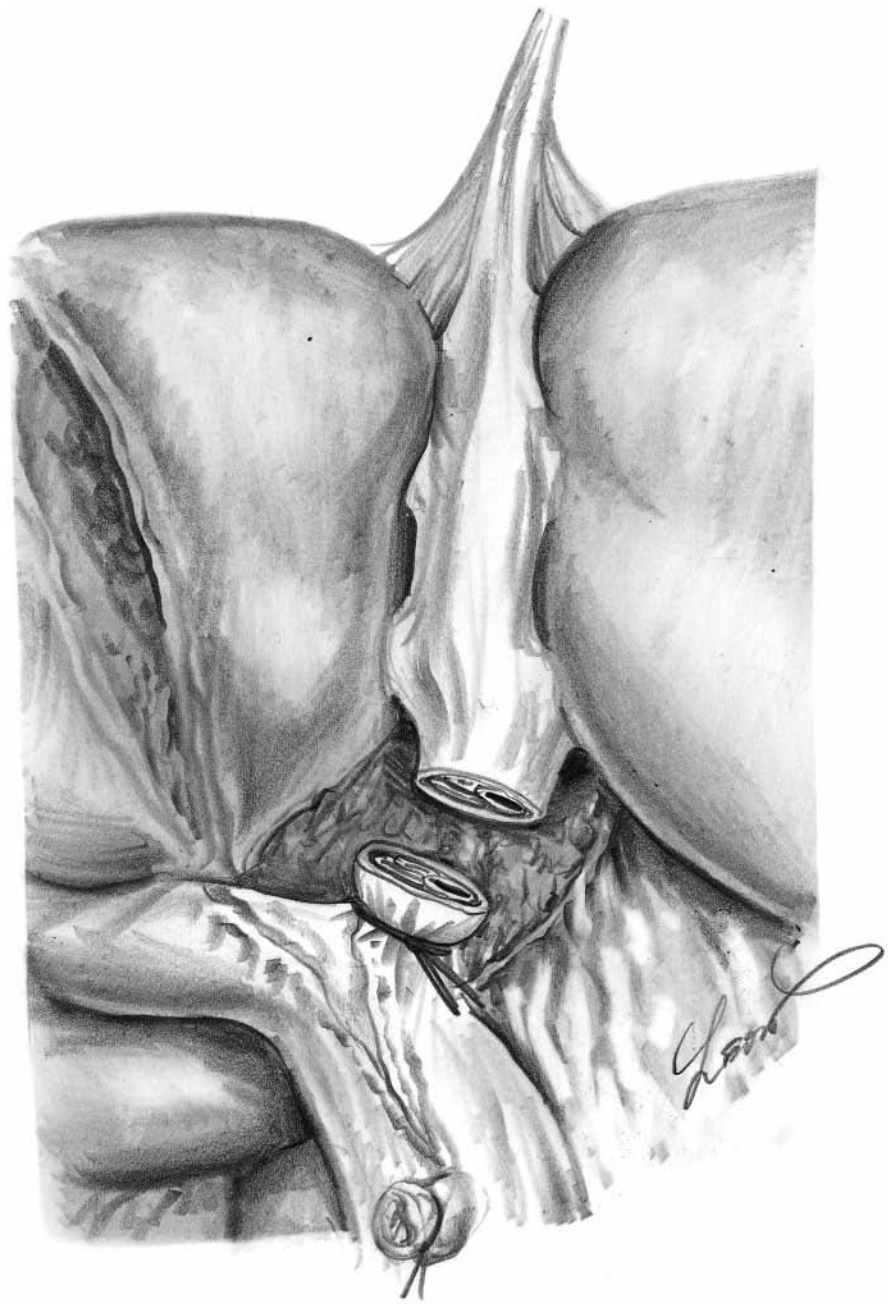
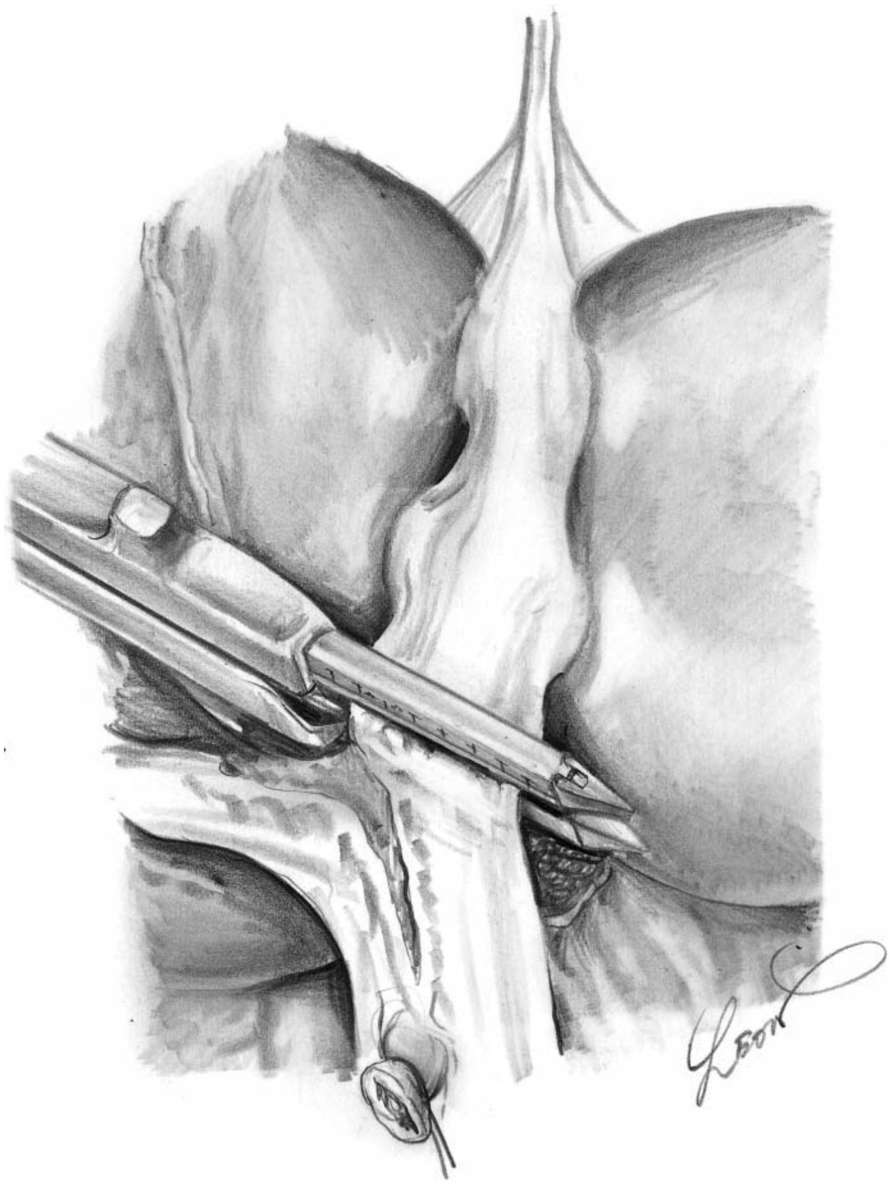
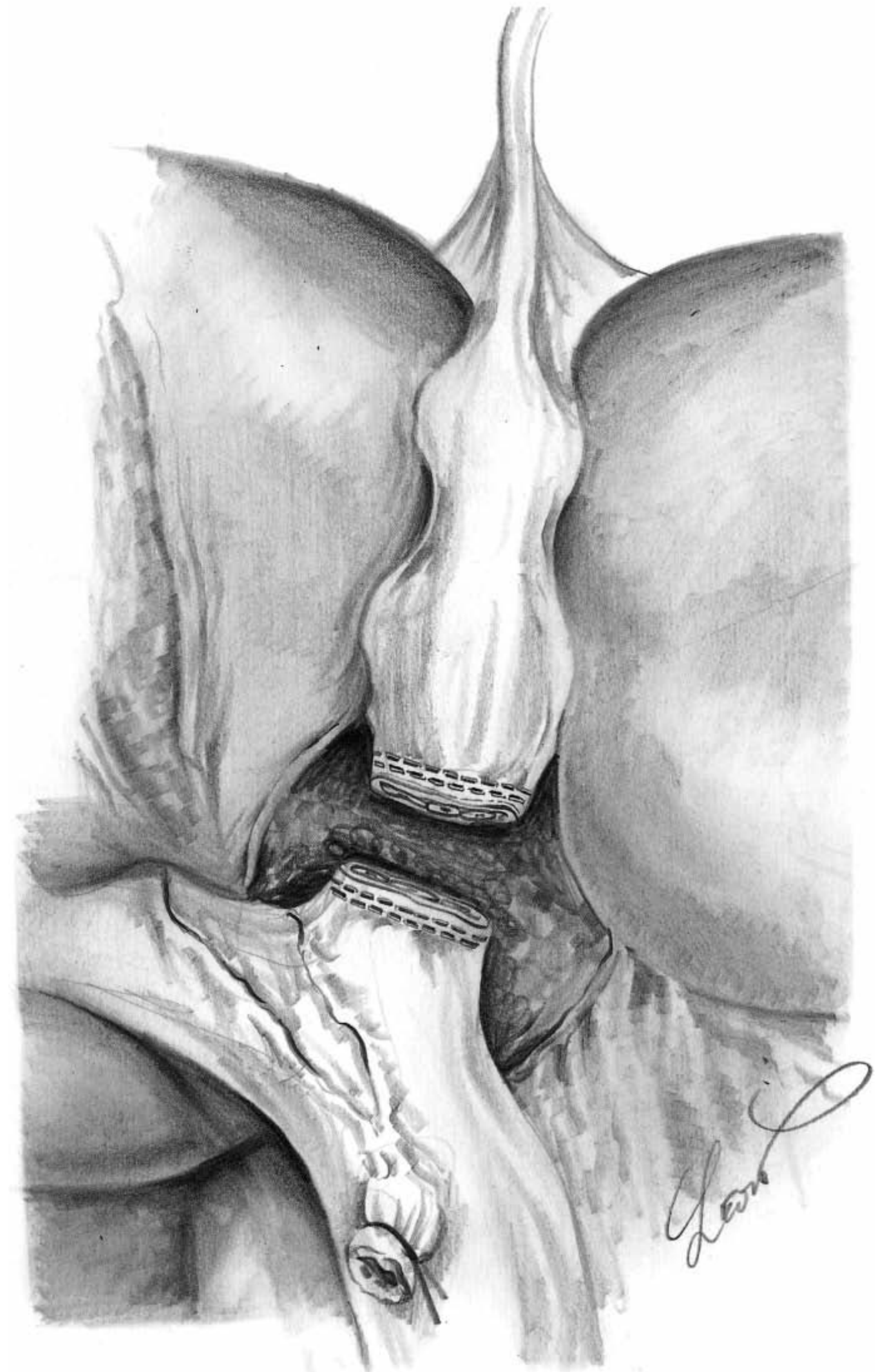


Fig. 5.44. Transection of left segmental branch is done at the level of the anterior surface of the lesser omentum



a

Fig. 5.45a. A liner cutter is useful when the root of the left segmental branch is wide



b

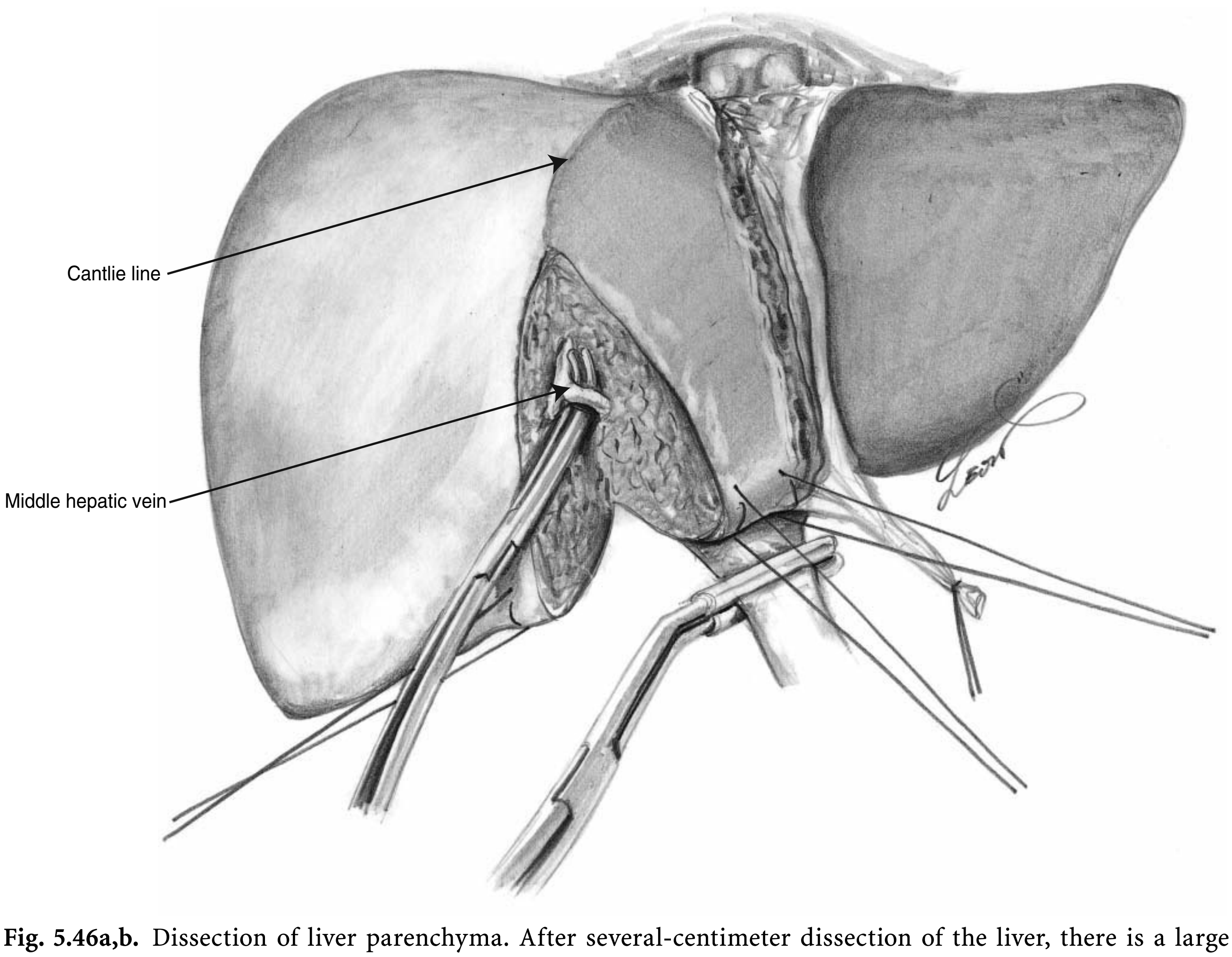
Fig. 5.45b. The left segmental branch is transected by a suture instrument

Mobilization of the Left Segment

Dissect the left part of the coronary ligament and the triangular ligament. After this procedure, the merging of the left hepatic vein and the middle hepatic vein entering the IVC comes into view.

Dissection of the Liver Parenchyma (Fig. 5.46a,b)

The dissection of the border with the middle segment is done on the demarcated line (Cantlie line). After dissecting several centimeters, there is a thick branch of the middle hepatic vein which drains the left segment. This branch must be cut, exerting care not to damage the middle hepatic vein. The dissection of the border with the caudate area is done on the face of the paracaval triangle.



a

Fig. 5.46a,b. Dissection of liver parenchyma. After several-centimeter dissection of the liver, there is a large hepatic branch ramified from the middle hepatic vein

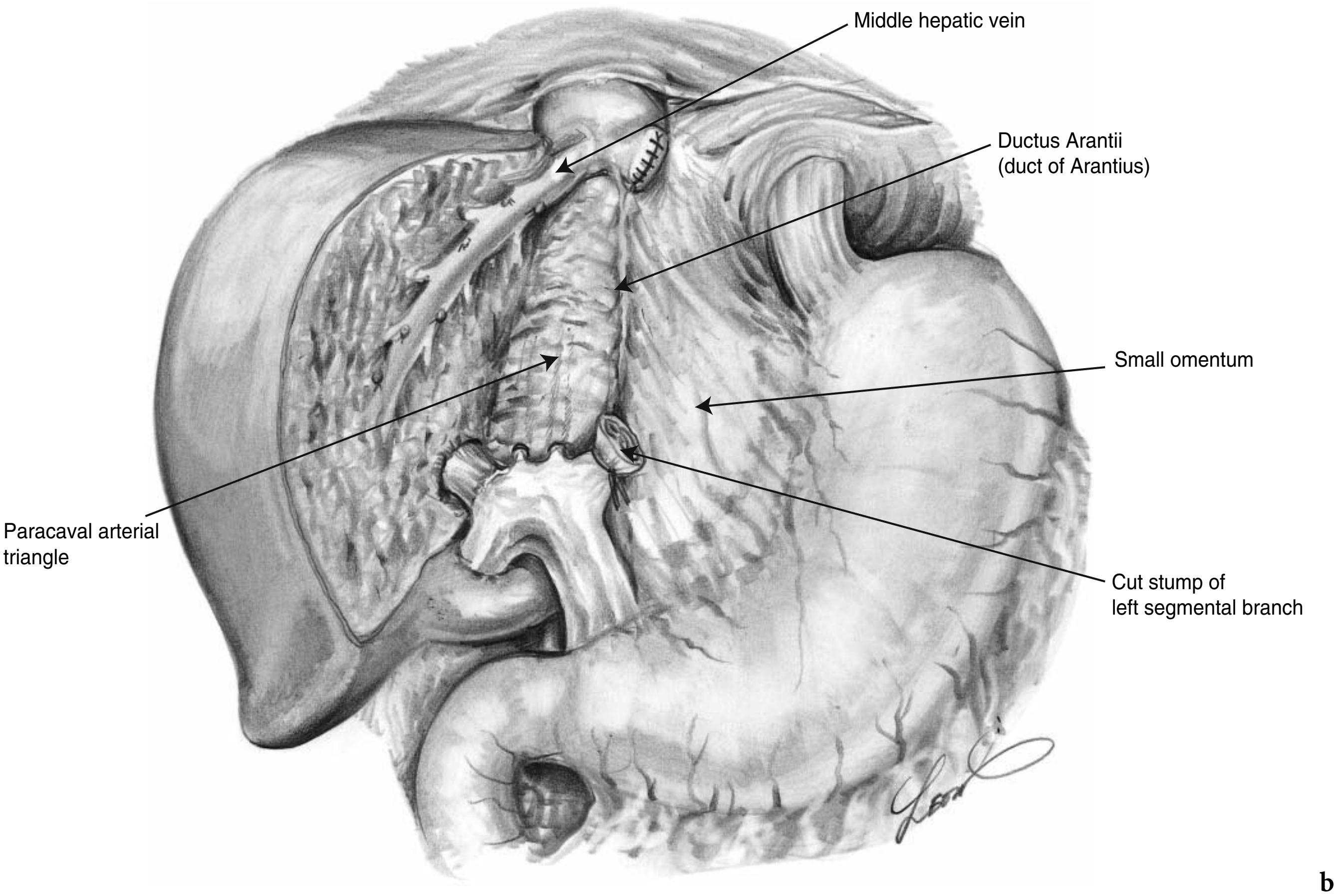


Fig. 5.46. *Continued*

Resection of the Two Right Segments (Right Lobectomy) (See DVD 1)

In this procedure, the right and middle segments are resected. This is commonly known as a "right lobectomy." Two segmental branches of the Glissonean pedicles are transected and the right hepatic vein is also transected at its root (Figs. 5.47, 5.48).

Incision

Make an abdominal reverse "T" incision.

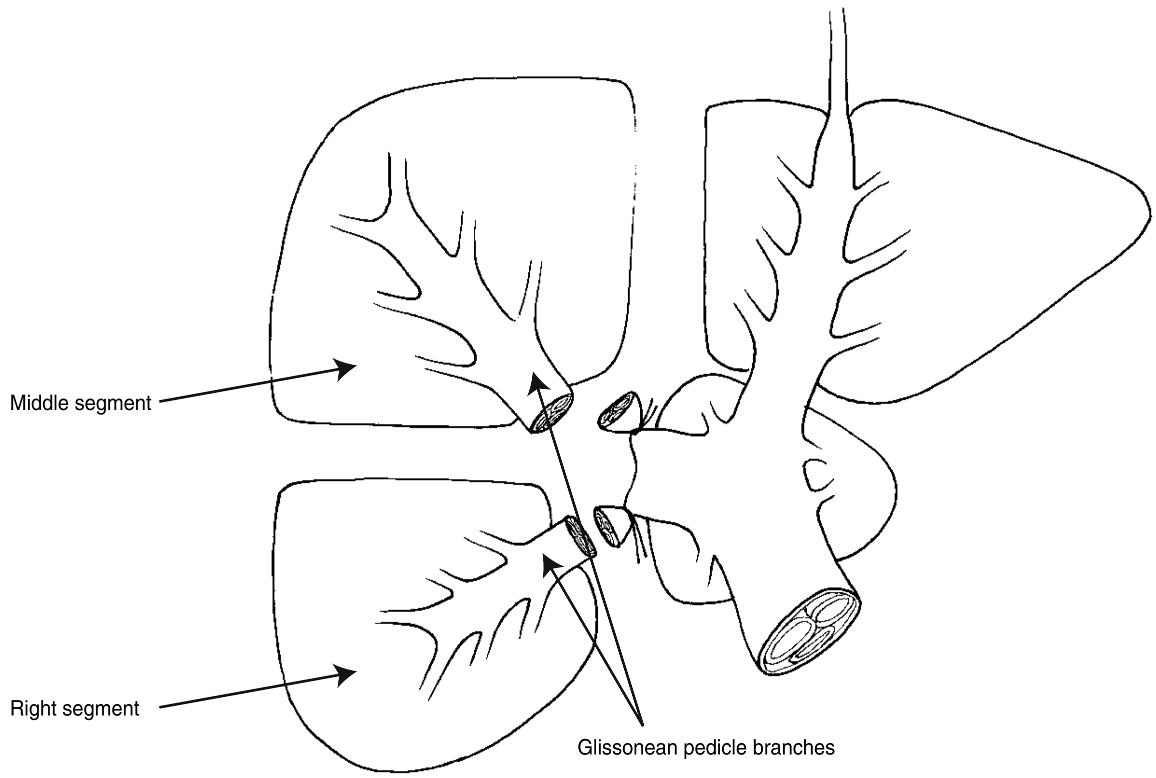


Fig. 5.47. Schema of resection of the two right segments. Middle and right segmental branches are transected at the first step

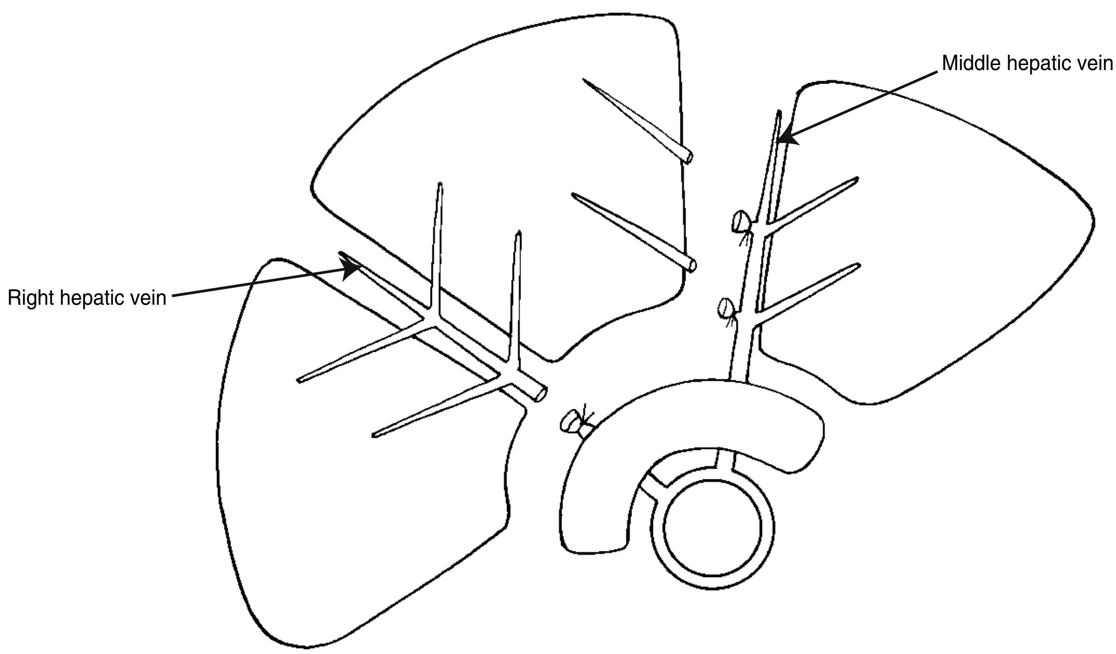


Fig. 5.48. Some hepatic vein branches ramified from middle hepatic vein and main trunk of right hepatic vein must be transected

Detachment of the Segmental Branches

The right and middle segmental branches are detached, ligated, and severed (Fig. 5.49).

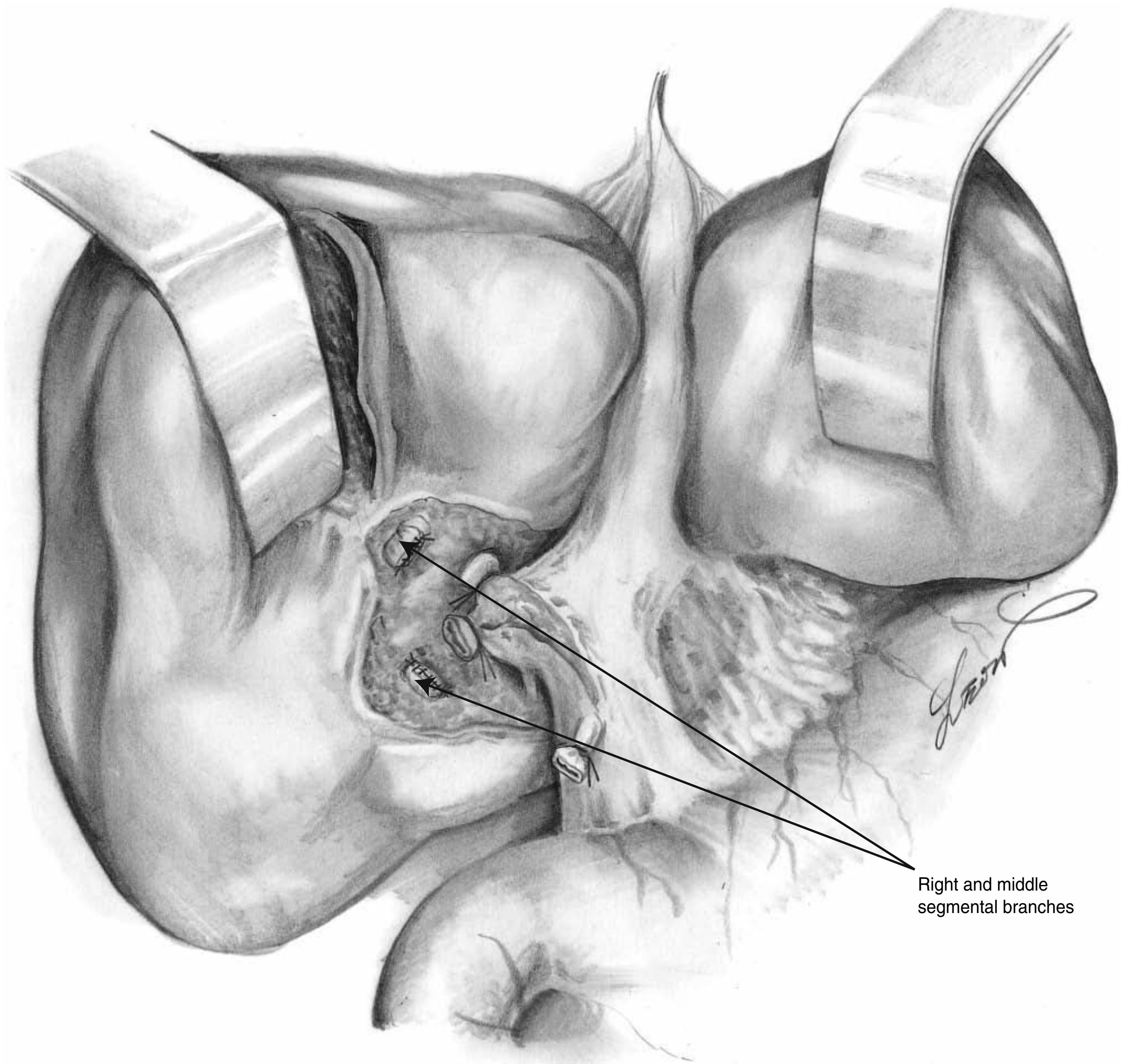


Fig. 5.49. Transection of right and middle segmental branches is completed. With this, manipulation at hepatic hilus is finished

Dissection of the Liver Parenchyma

This is performed in the same manner as in middle segmentectomy. In a right lobectomy or extended right lobectomy, the anterior approach technique (see below) must be used to prevent intraoperative dissemination of tumor cells.

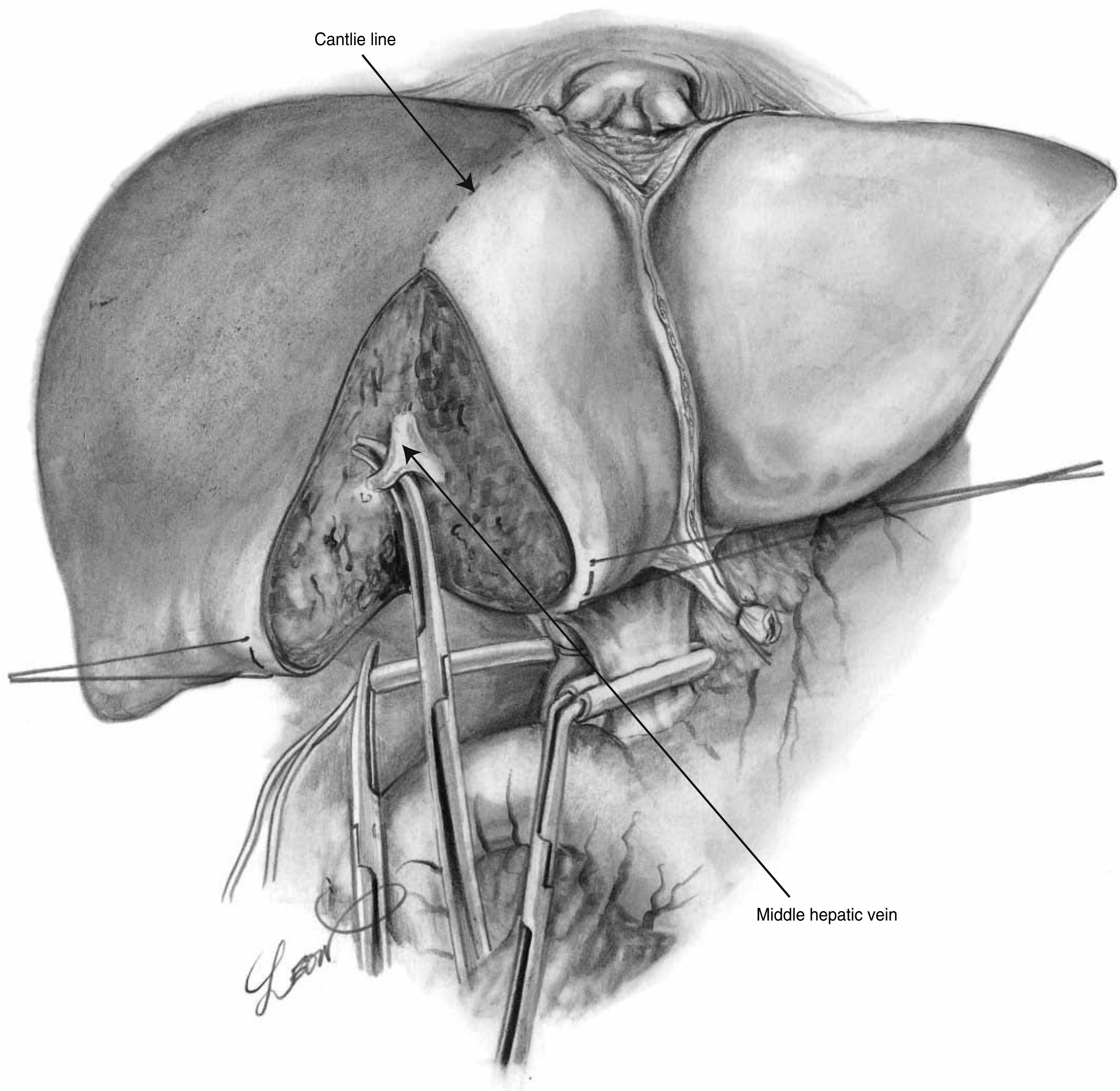


Fig. 5.50. After several-centimeter dissection, a large hepatic vein is bifurcated from the middle hepatic vein

Transection of the Right Hepatic Vein (Fig. 5.51)

Dissection of the liver parenchyma is started on the mark of the caudate process and carried cranially along the right margin of the IVC, extending to the edge of the right hepatic vein. Figure 5.52 shows completion of right lobectomy.

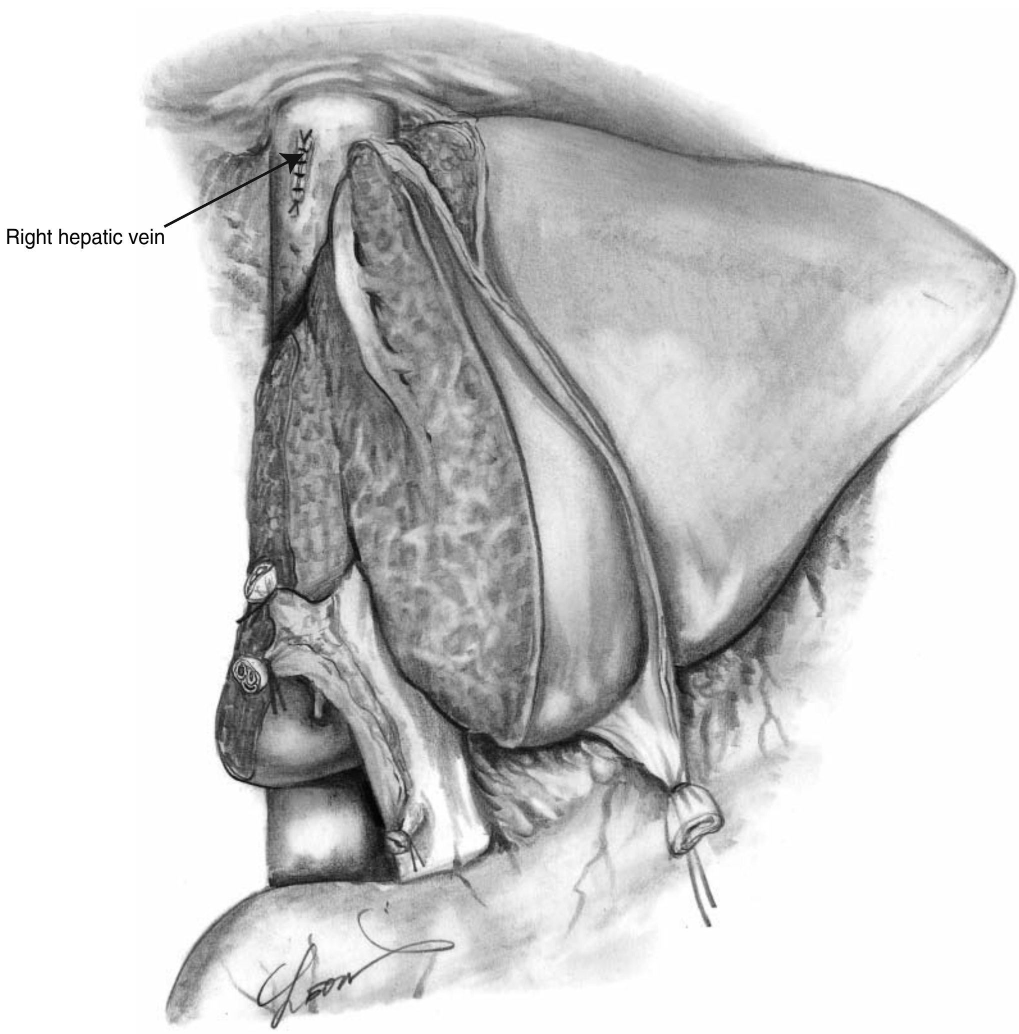


Fig. 5.51. Transection of right hepatic vein. Liver parenchymal dissection via anterior approach reaches the IVC and origin of right hepatic vein

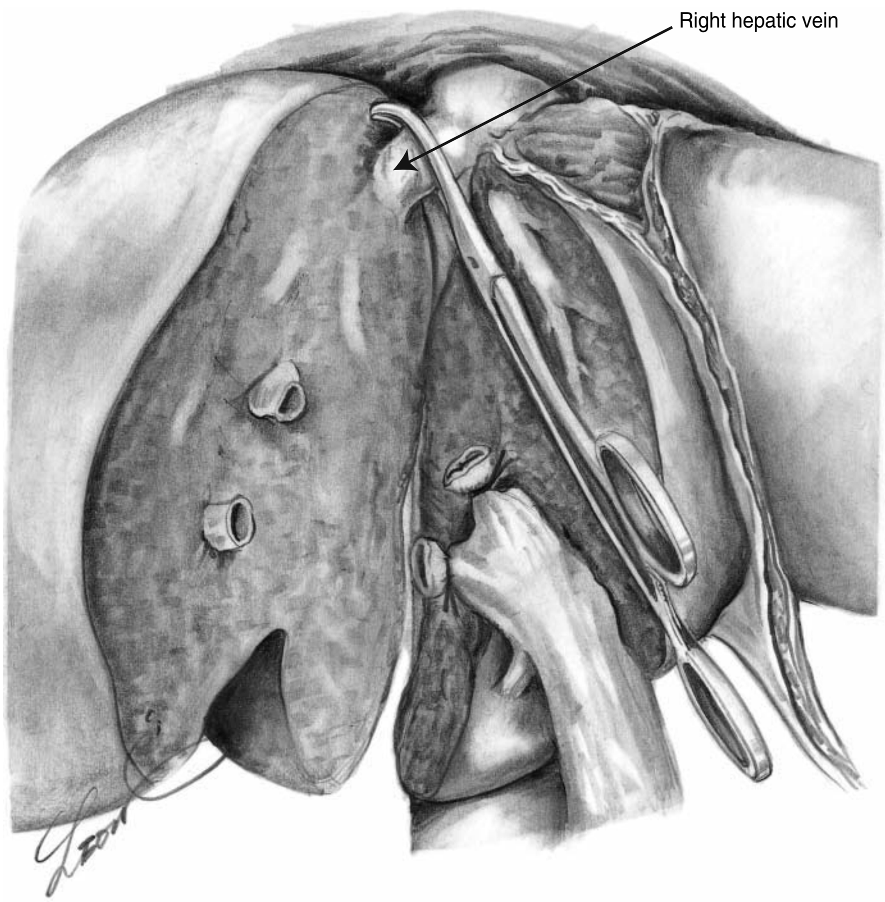


Fig. 5.52. Completion of right lobectomy

Anterior Approach Technique (See DVD 1)

In right lobectomy or extended right lobectomy, mobilization of the right lobe is difficult and sometimes dangerous because of the possibility of massive bleeding. If the tumor is malignant, there is a great danger of intraoperative dissemination of tumor cells. Therefore, in such a case, the liver dissection must be done without mobilization, i.e., using the non-touch isolation technique—a procedure referred to as the anterior approach.

The resection begins from the anterior surface of the liver and extends to the IVC. Then the right hepatic vein and some short hepatic veins are ligated and transected from the inside at the bottom edge of the cut surface. After that, the right lobe is devascularized; it can then be mobilized and removed at once.

Right Trisegmentectomy (Resection of Two and a Half Segments)

In this procedure the right and middle segments and the left medial area are resected. This is classically referred to as extended right lobectomy or right trisegmentectomy (Fig. 5.53).

Incision

An upper abdominal reverse T-incision is routinely made.

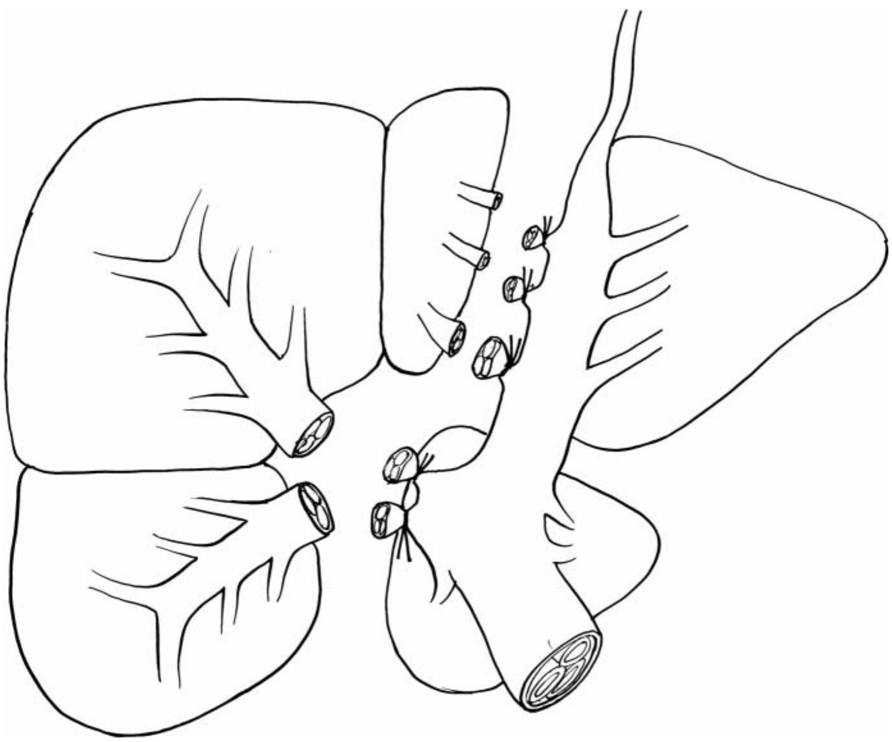
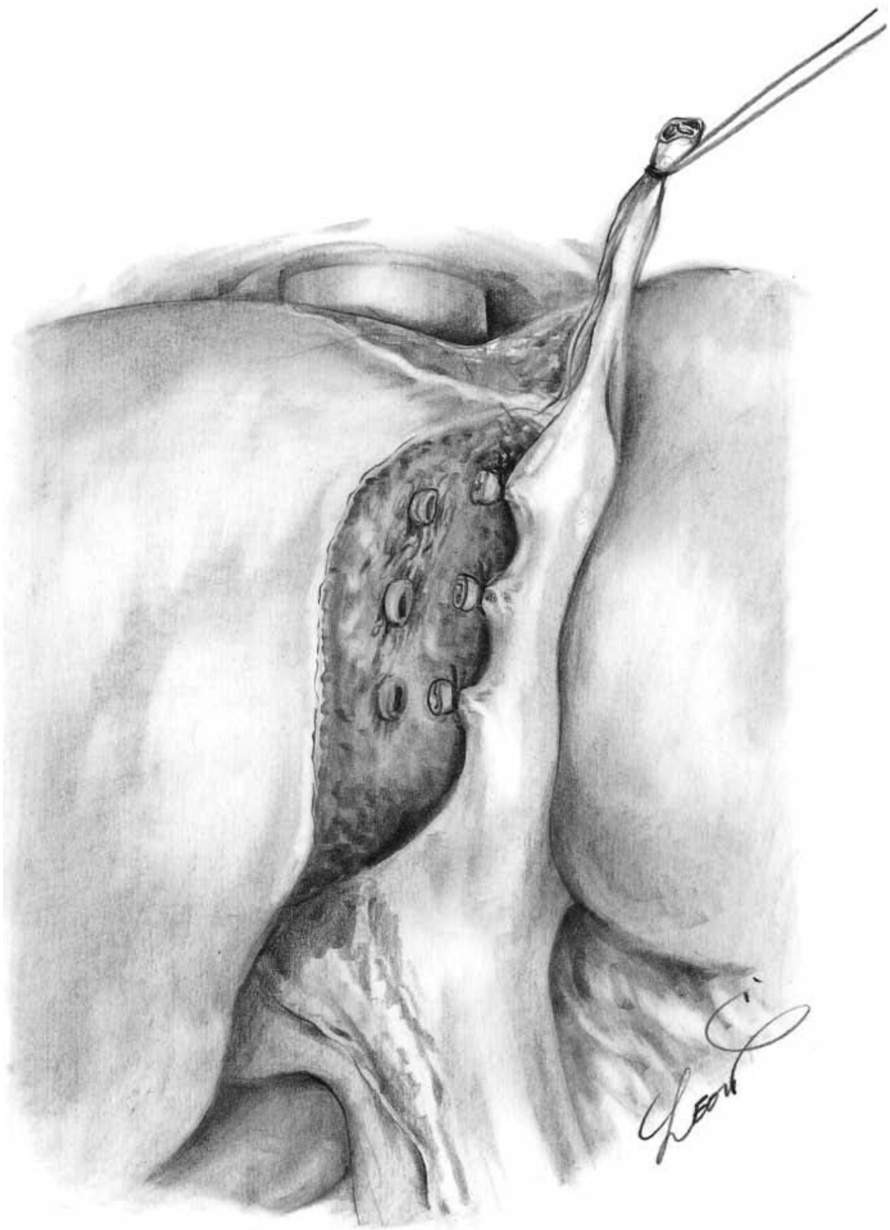


Fig. 5.53. Schema of right trisegmentectomy. Some tertiary branches of left segmental branch and middle and right segmental pedicles are transected

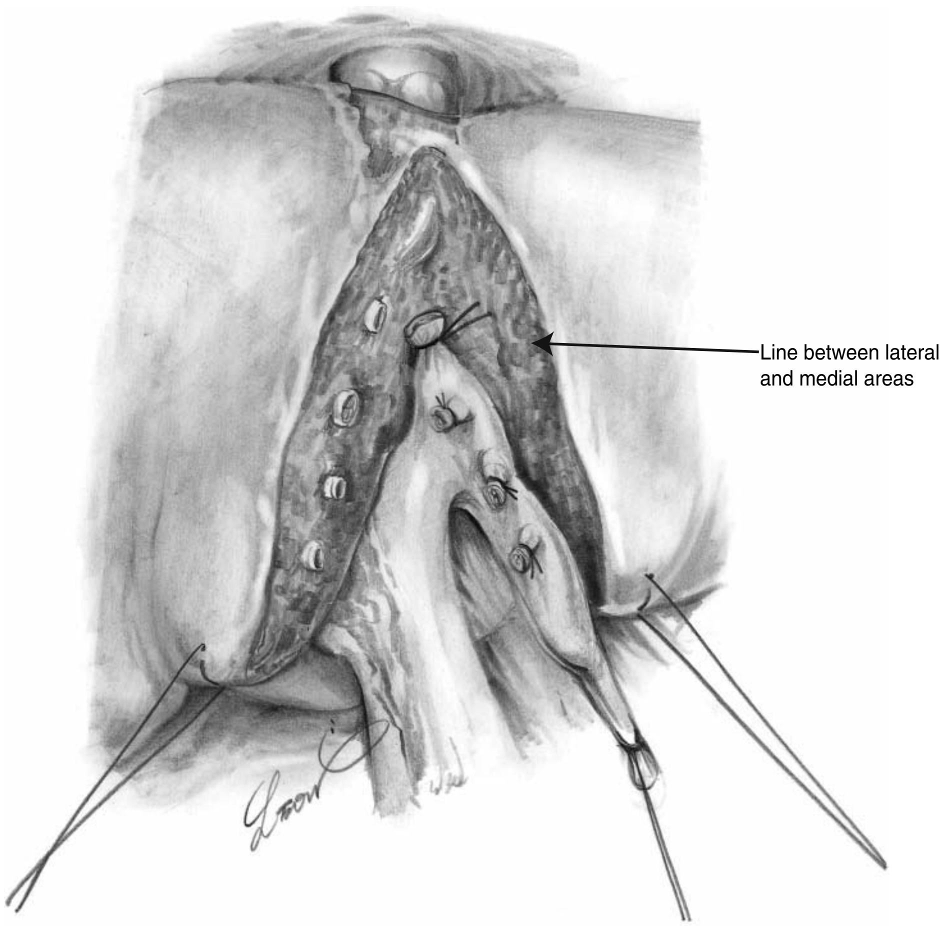
Separation of the Glissonean Pedicles (Fig. 5.54a,b)

The tertiary branches of the left medial area are transected first. All these tertiary branches come directly from the right side of the left segmental branch of the Glissonean pedicle. Each of these branches must be cut at its base. Dissection of the liver is done on the line between the lateral and medial areas and also on the paracaval triangle (Fig. 5.55).



a

Fig. 5.54a. Separation of the Glissonean pedicles. Transection of several numbers of tertiary branches ramified from left segmental pedicle



b

Fig. 5.54b. Liver dissection is done on the demarcated line to the imaginary line A–B

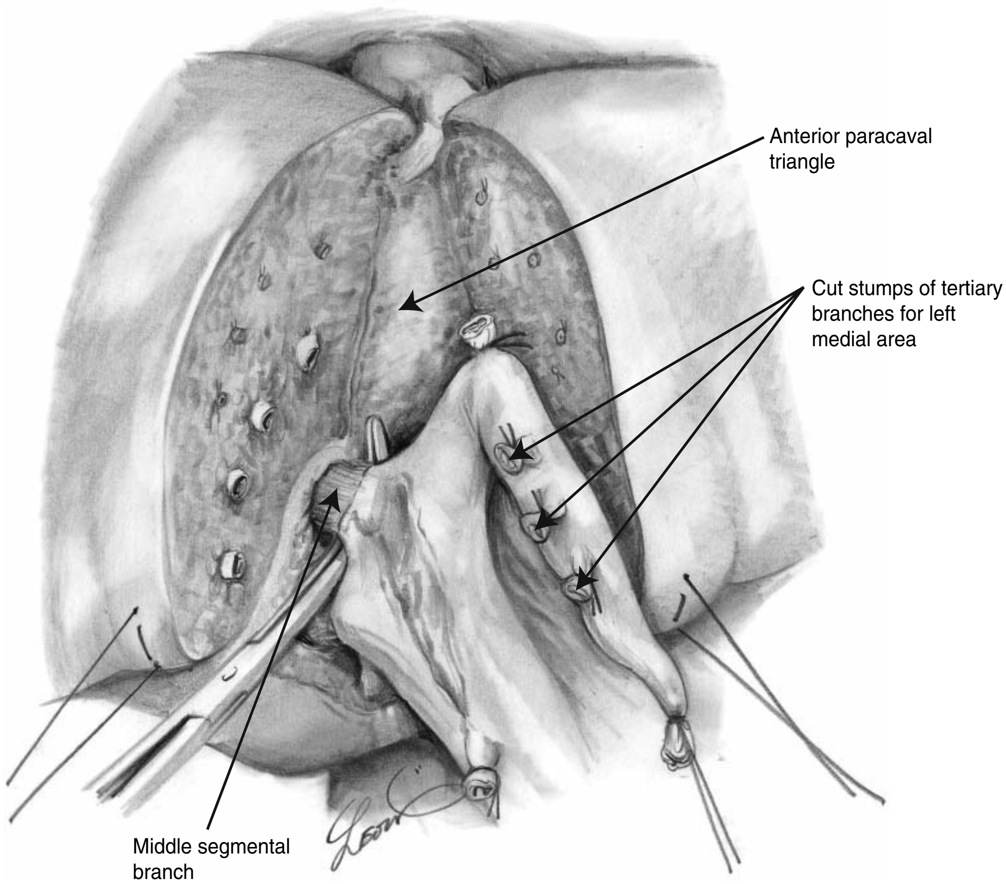


Fig. 5.55. Dissection of the liver along the anterior paracaval triangle

After dissection of the liver, the hepatic hilum is open. After that, the middle and right segmental branches of the Glissonean pedicles are easily ligated and cut (Fig. 5.56).

By these procedures, the part of the liver to be resected is freed from the Glissonean pedicle (Fig. 5.57a,b).

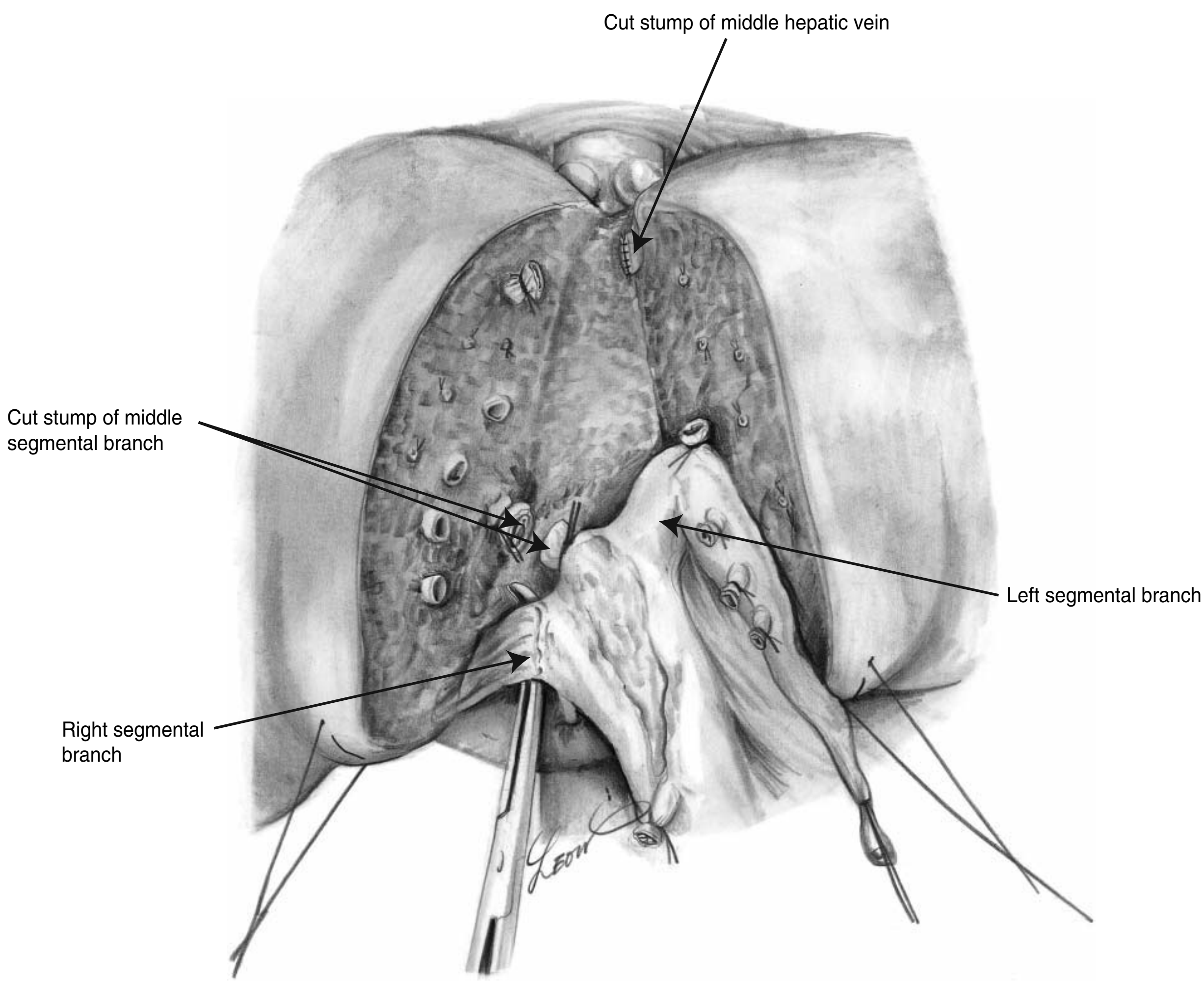
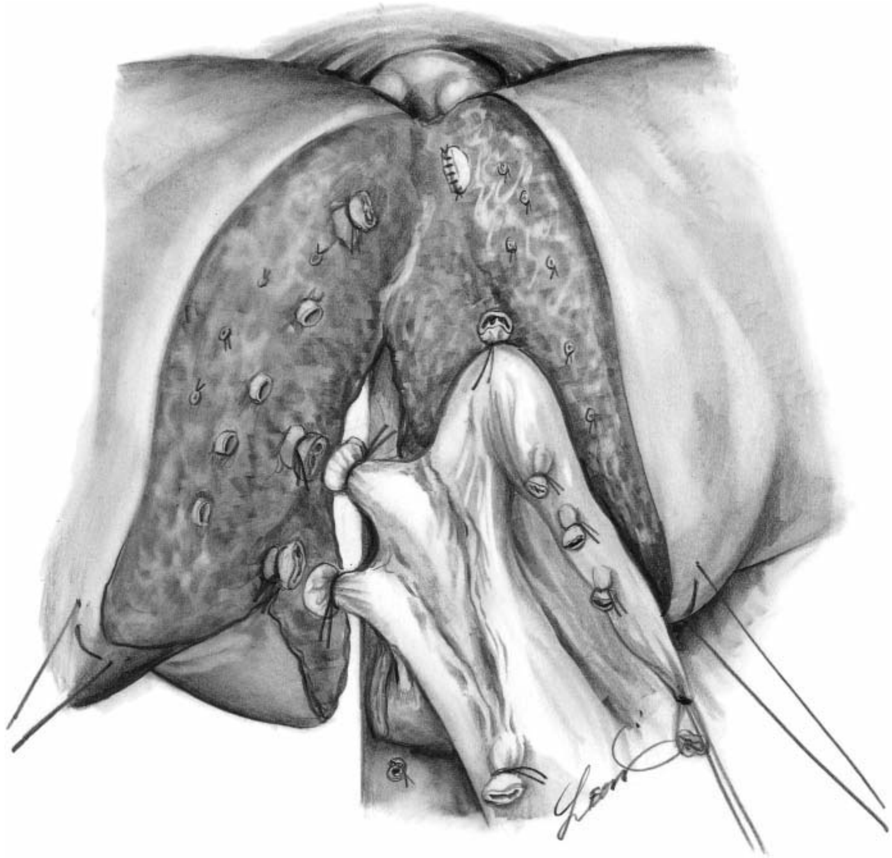


Fig. 5.56. After dissection of the liver on the planes between left lateral area and intersegmental plane between caudate area, middle and right segmental pedicles are transected

Fig. 5.57a. Dissection of the liver is continued after a cut of middle hepatic vein toward the IVC and origin of the right hepatic vein



a

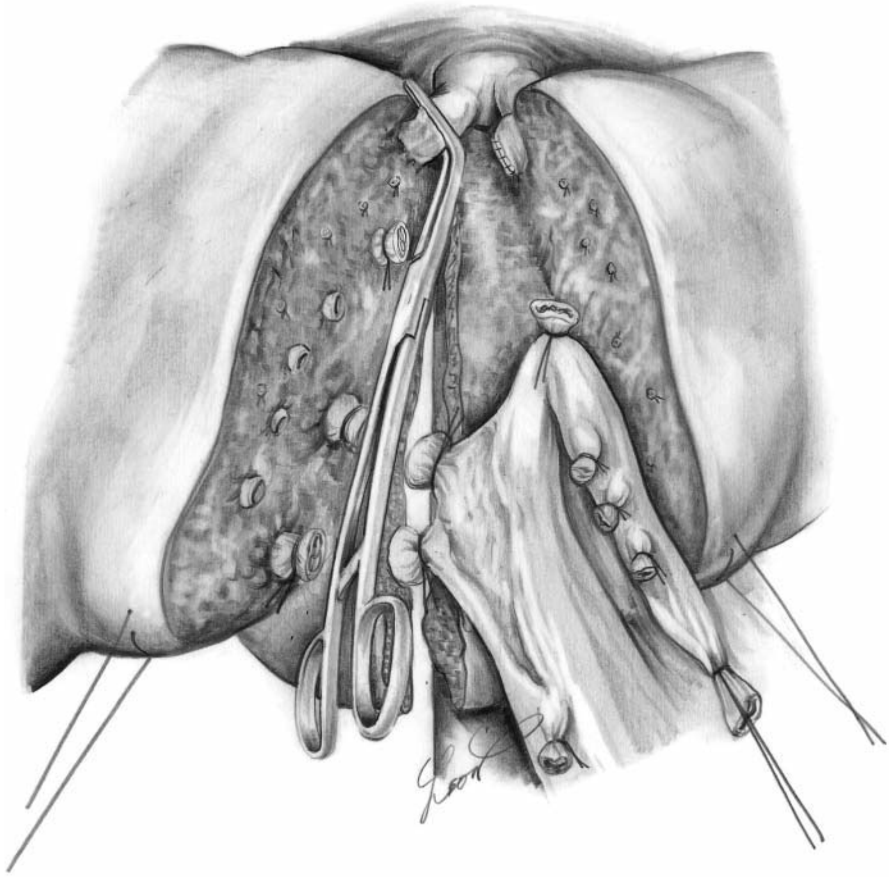


Fig. 5.57b. Last, right hepatic vein is cut

b

Dissection of the Liver Parenchyma

This procedure is usually done by the anterior approach. The liver is dissected just up to the IVC. In this operation, both the right and middle hepatic veins and several short hepatic veins are dissected at inside the liver. Figure 5.58 shows completion of right trisegmentectomy.

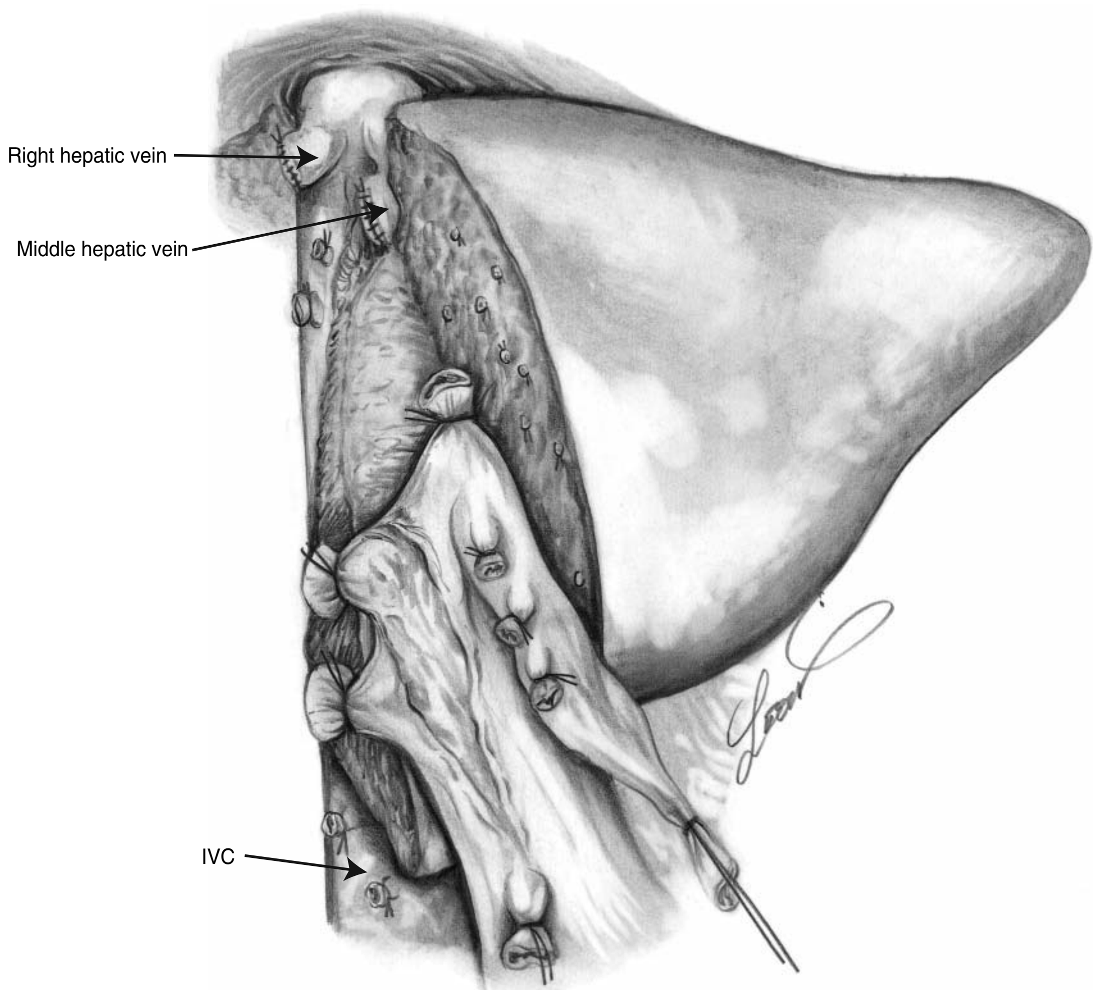


Fig. 5.58. Completion of right trisegmentectomy

6 Resection of the Caudate Area (i.e., Spiegel Area and Caudate Process) (See DVD 2)

Several thin feeders of the caudate area ramify from the right and left primary branches. The caudate area is bound to all three segments and encloses the IVC. Some short hepatic veins flow into the IVC (Figs. 6.1, 6.2).

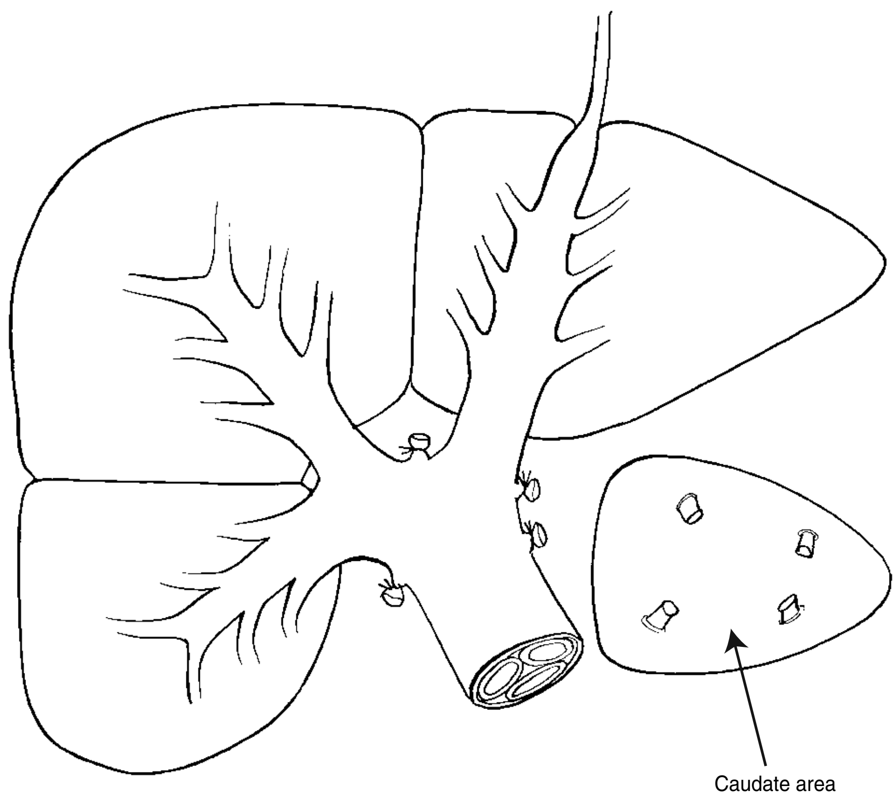


Fig. 6.1. Schema of resection of caudate area. Glissonean branch to the caudate area is ramified from main trunk and both primary branches of Glissonean pedicle outside the liver

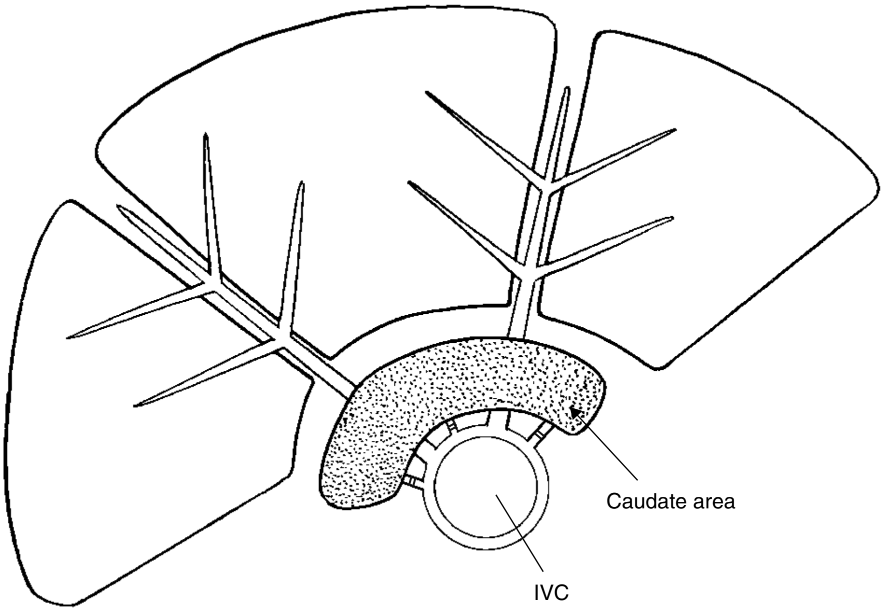
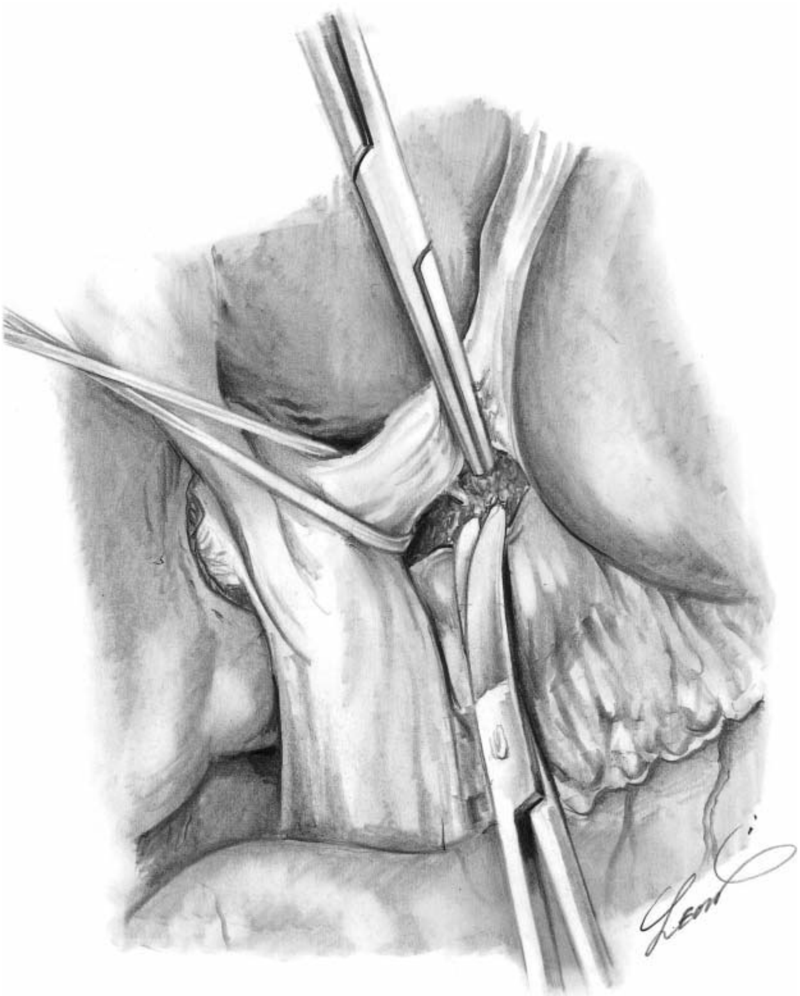


Fig. 6.2. Schema of resection of caudate area, showing some short hepatic veins must be cut

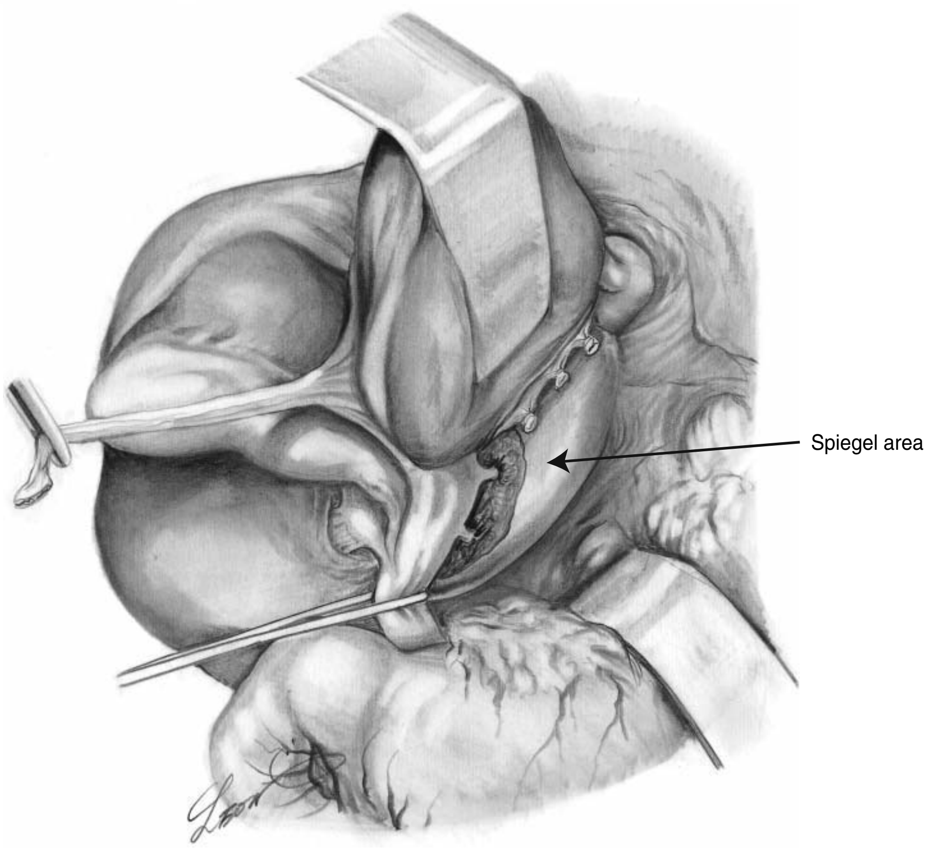
Resection of the Spiegel Area (Fig. 6.3a,b)

Detach the left primary branch of the Glissonean pedicle from the hilum of the liver and pull up this branch to expose the Glissonean pedicles which feed the Spiegel area. It is easy to ligate these small branches one after the other. The short hepatic veins are transected by moving the Spiegel area upward (Fig. 6.4). Liver dissection should be done along the IVC (Fig. 6.5).



a

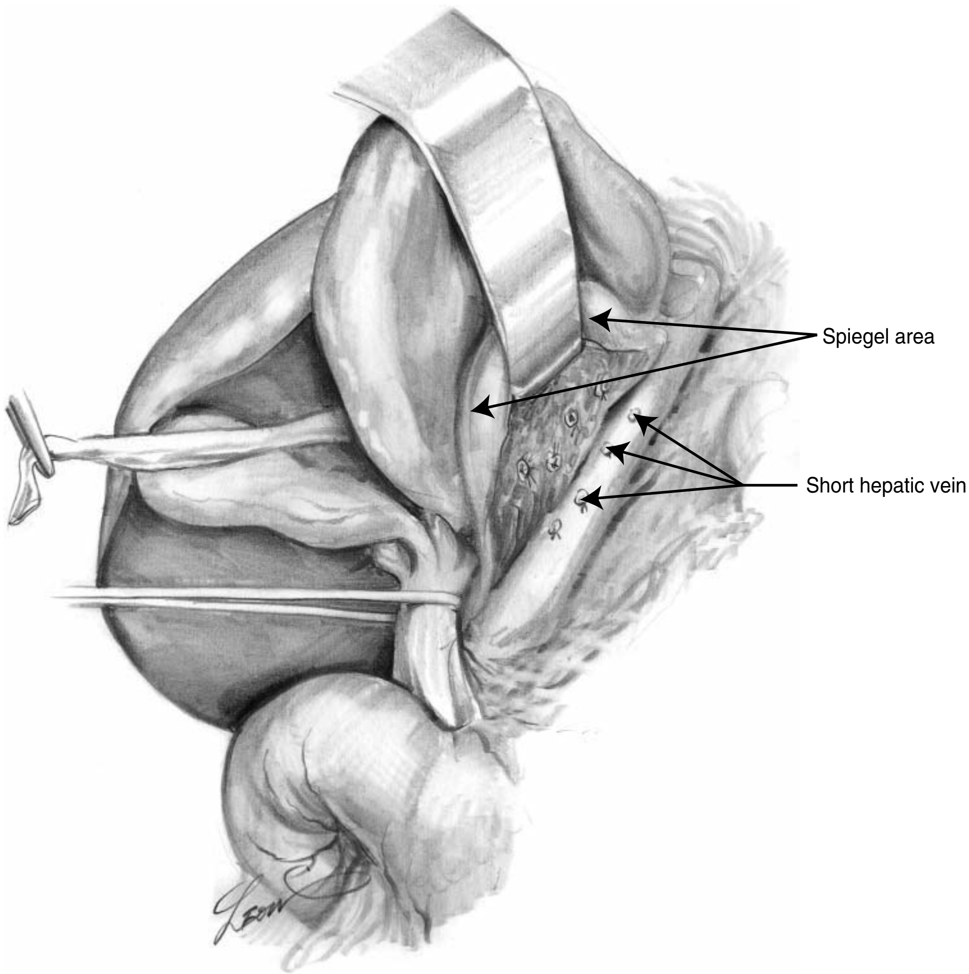
Fig. 6.3a. Glissonean branch to the Spiegel area is ramified from left primary Glissonean pedicles



b

Fig. 6.3b. There are several numbers of Glissonean branches behind the left primary branch

Fig. 6.4. Transection of short hepatic veins



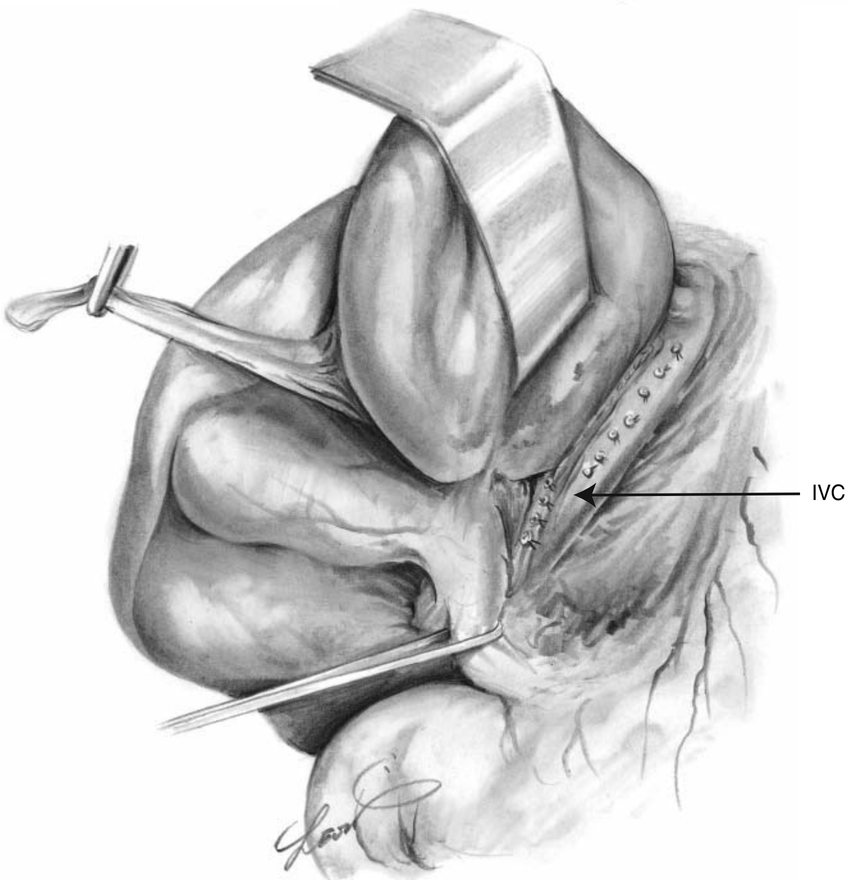


Fig. 6.5. Liver dissection along the IVC

Resection of the Caudate Process Area

The hepatoduodenal ligament is taped and pulled up perpendicularly, exposing several small branches nourishing the caudate area behind the right and left primary branches. The right primary branch of the Glissonean pedicle is detached from the hepatic hilum (Fig. 6.6). Pull this branch upward and detach the surrounding liver parenchyma. There are some short Glissonean

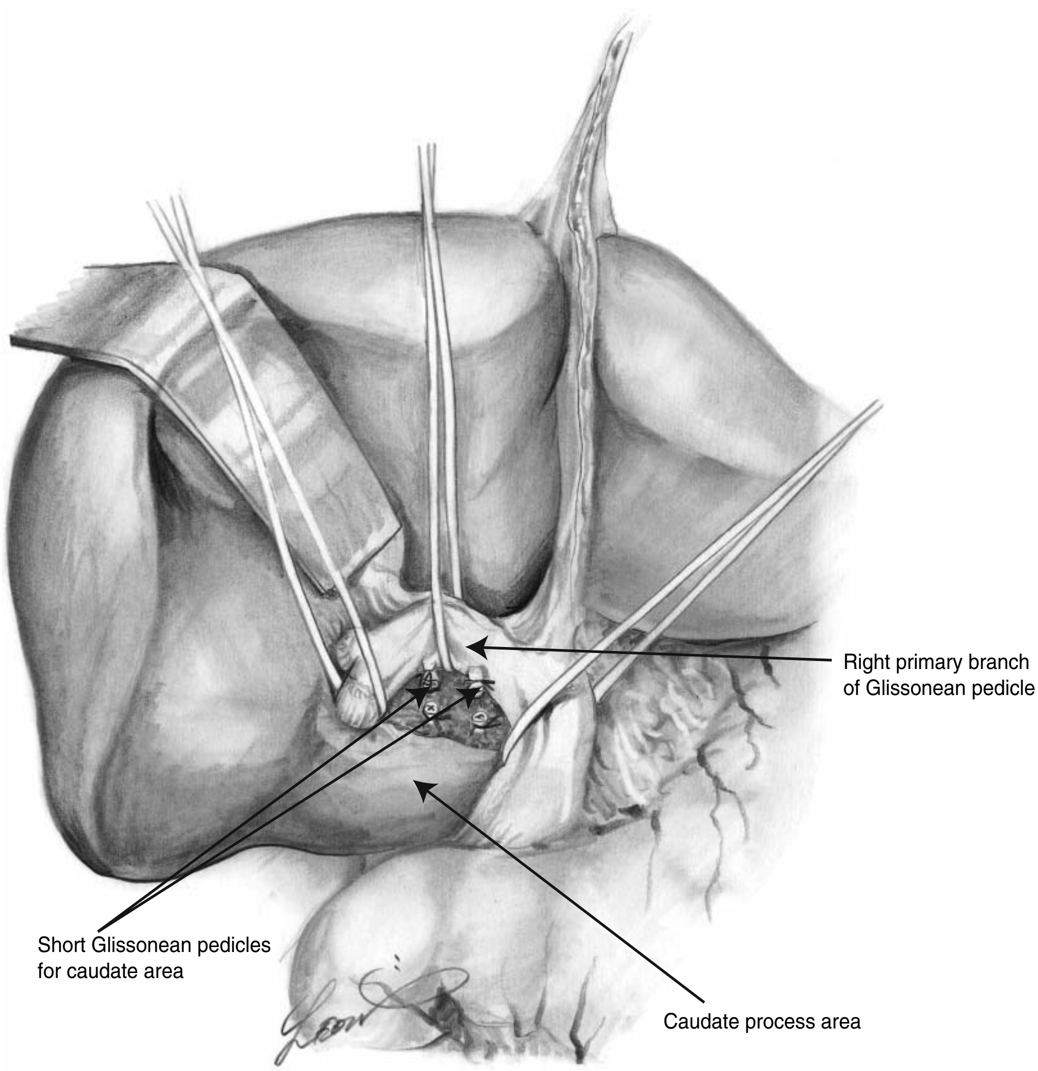


Fig. 6.6. Right primary branch of the Glissonean pedicle is detached from the hepatic hilum

pedicles ramifying from the right primary branch. These are each transected, one by one. After the caudate process area is resected, the right inferior hepatic vein is exposed at the cut surface between the right segment and the caudate area (Fig. 6.7). Total caudate area resection is done after several thin Glissonean pedicles branching from the right and left primary branches have been transected (Fig. 6.8).

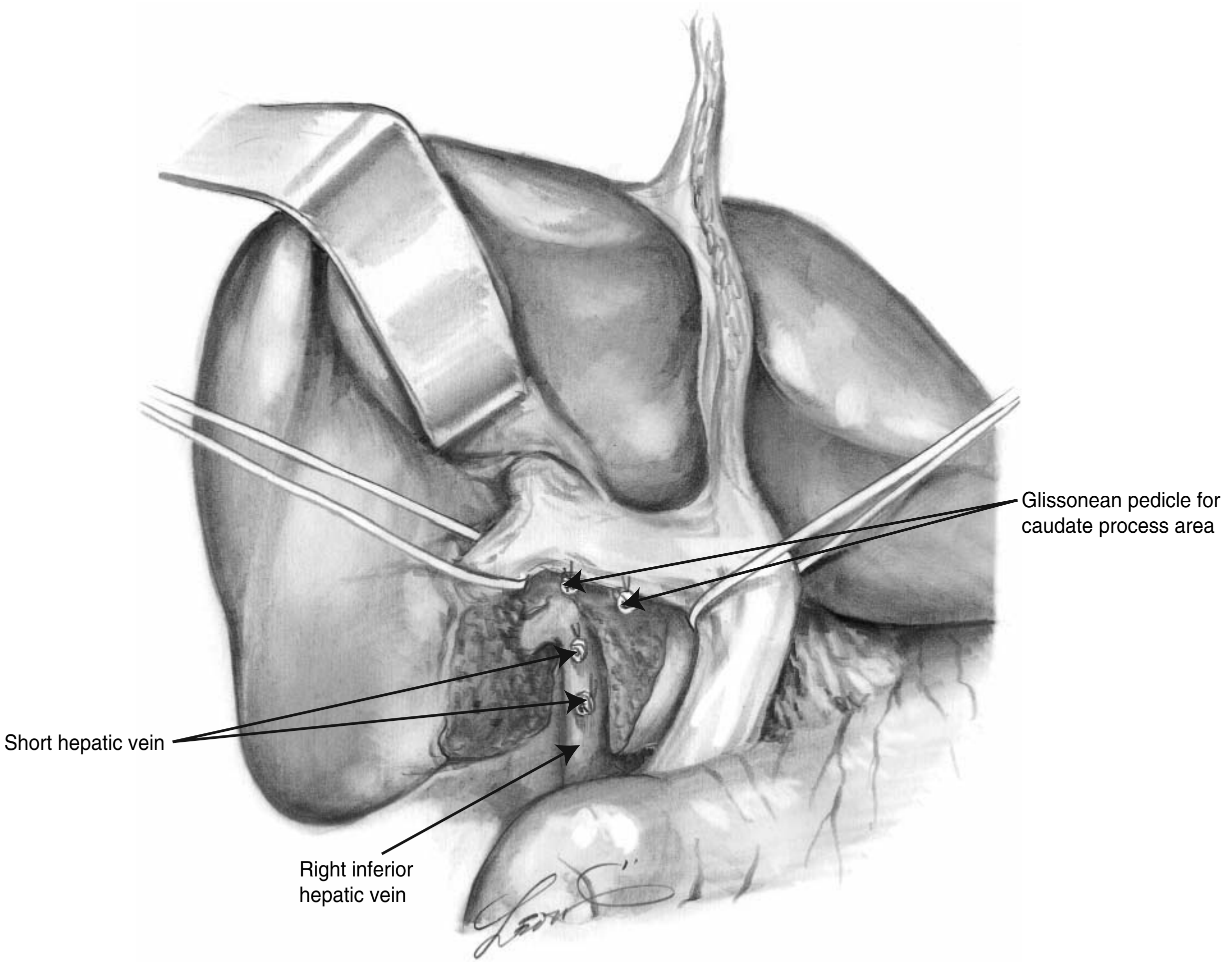


Fig. 6.7. Exposure of right inferior hepatic vein

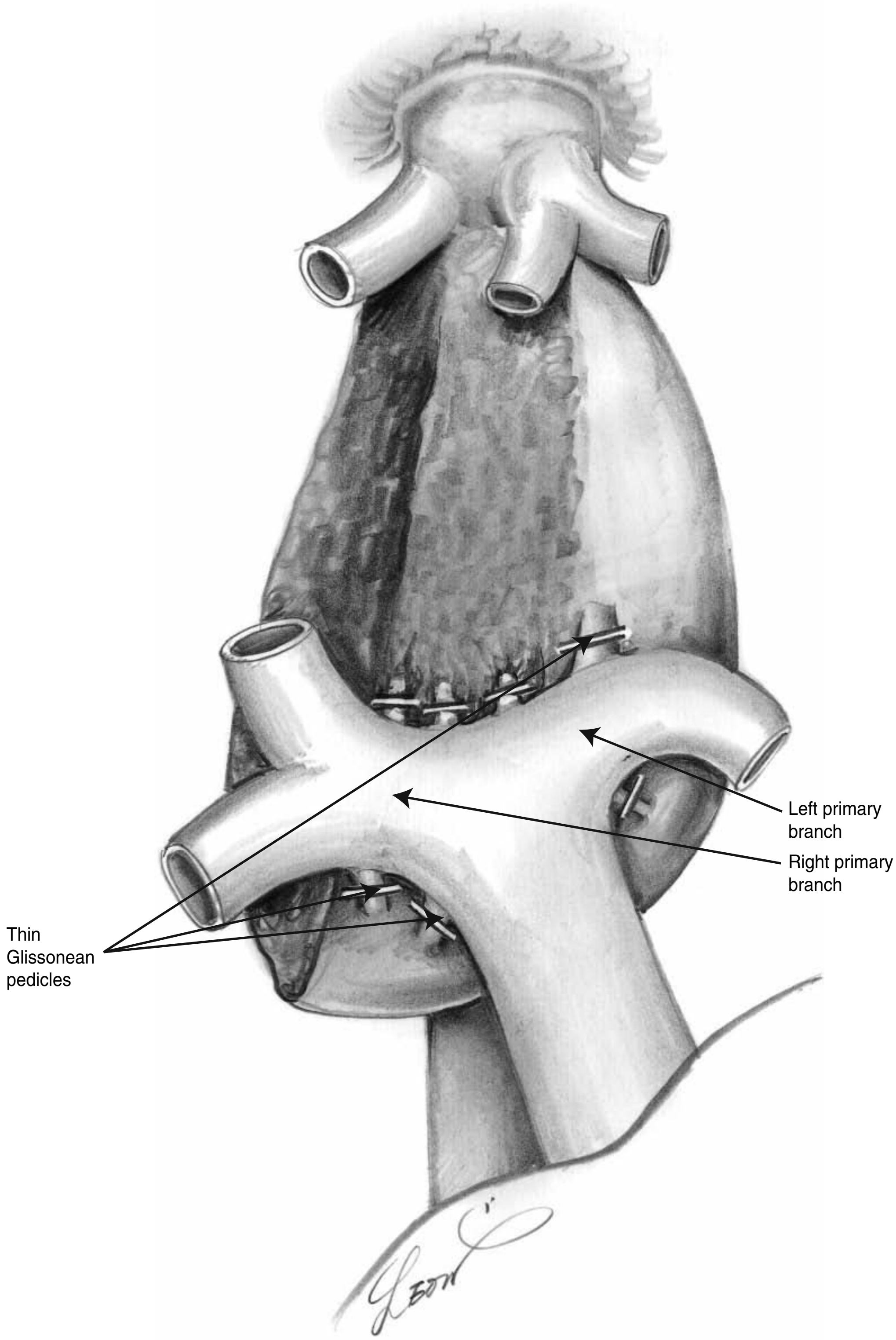


Fig. 6.8. Total caudate area resection

The border of the parenchyma between the right segment and the caudate area is dissected on the lateral triangle (Fig. 6.9). The border between the left segment and the caudate area is dissected on the paracaval triangle by the right lateral approach, after mobilization of the right lobe (Fig. 6.10).

The total caudate area resection is completed (Fig. 6.11). The remaining liver is connected only to the main hepatic veins.

Fig. 6.9. Dissection on lateral triangle and paracaval triangle

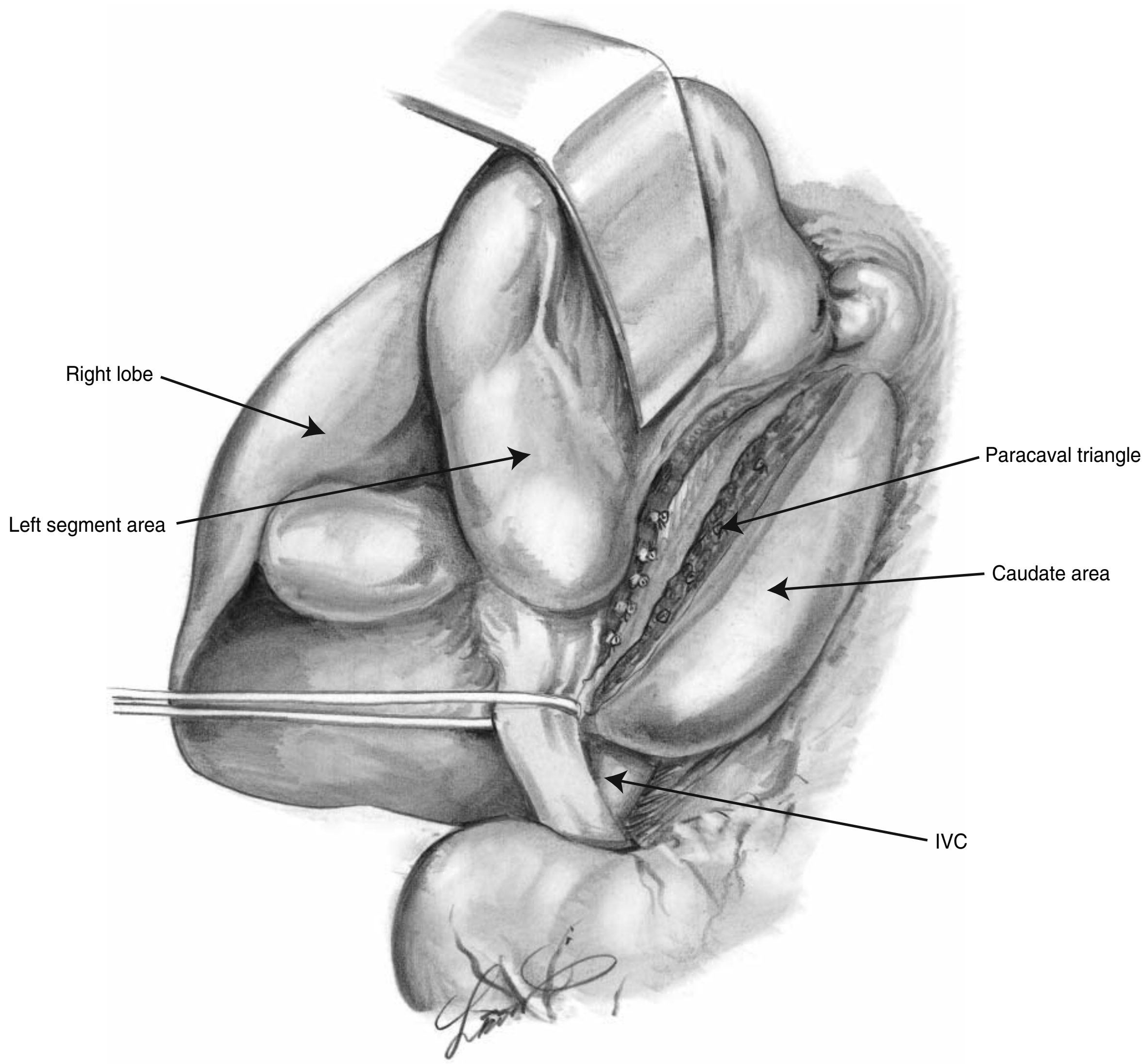


Fig. 6.10. Dissection on paracaval triangle

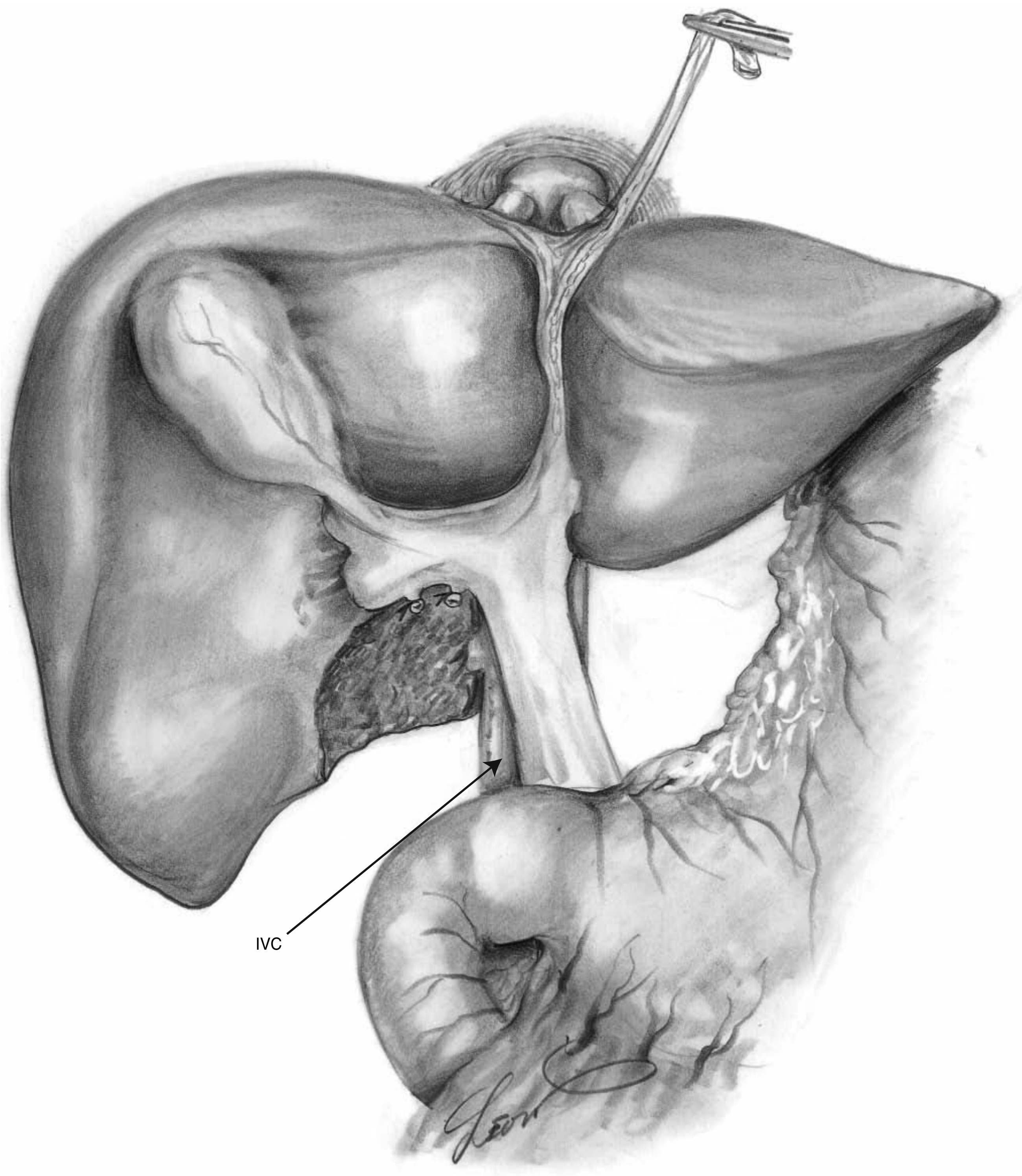


Fig. 6.11. Completion of total caudate area resection

7 Hepatic Cone Unit Resection (Anatomical Subsegmentectomy)

This is a method by which part of a segment is resected systematically, taking "cone unit(s)" into consideration, i.e., so-called Couinaud's segment resection. Four or five cone units correspond to one Couinaud's segment. The number of cone units to be resected depends upon the size and location of the tumor.

Here the cone unit resection is explained, using a cauliflower as a model (Fig. 7.1). The trunk of the cauliflower corresponds to the segmental branch of the liver and the stalks represent the liver tertiary branches. Each stalk with the cauliflower clump on top represents a liver cone unit. One of the stalks is ligated and then a dye solution is introduced (Fig. 7.2). The pigmented part represents a cone unit. The pigmented part is then removed (Fig. 7.3). Figure 7.4 shows a three-cone-unit resection and resected specimen (Fig. 7.5).

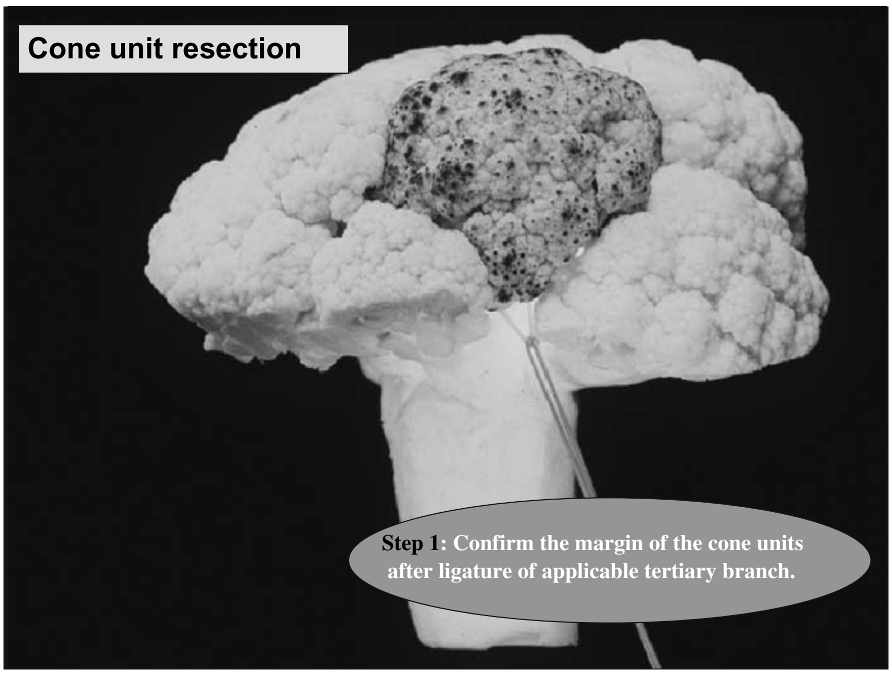


Fig. 7.1. (Step 1) One of stalk is ligated

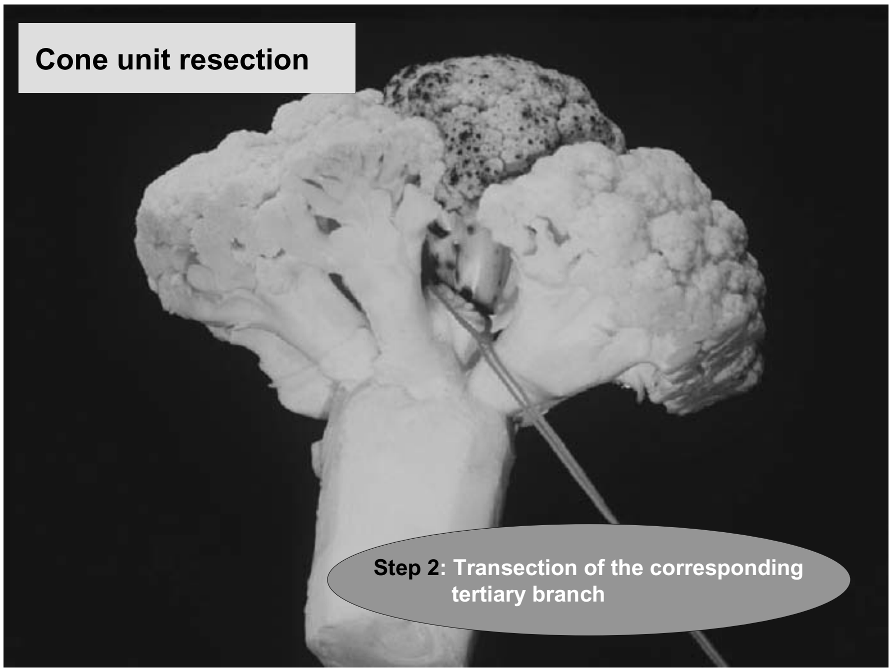


Fig. 7.2. (Step 2) One cone unit is pigmented

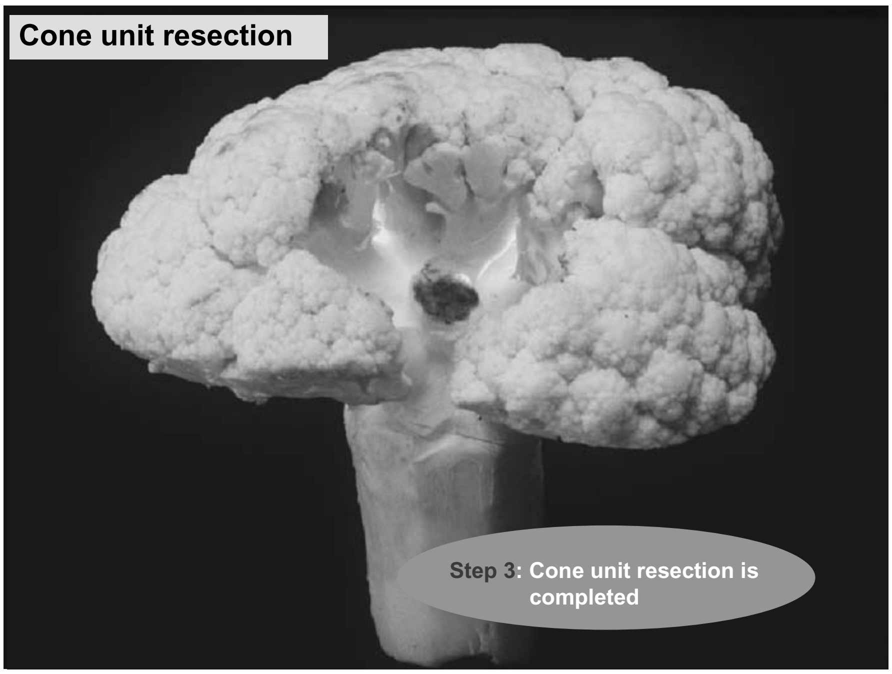


Fig. 7.3. (Step 3) Pigmented area is removed

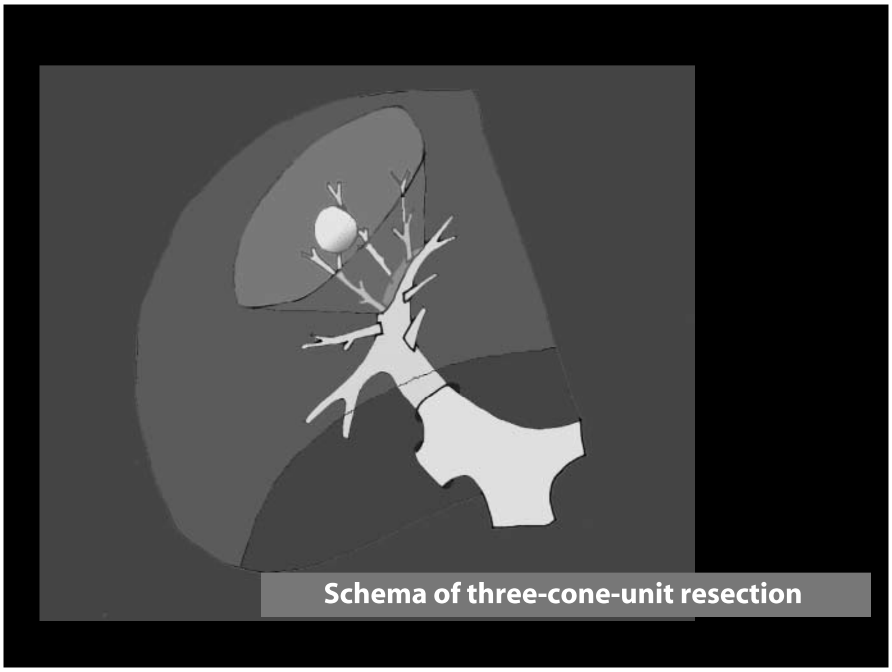


Fig. 7.4. Schema of resection of three cone units

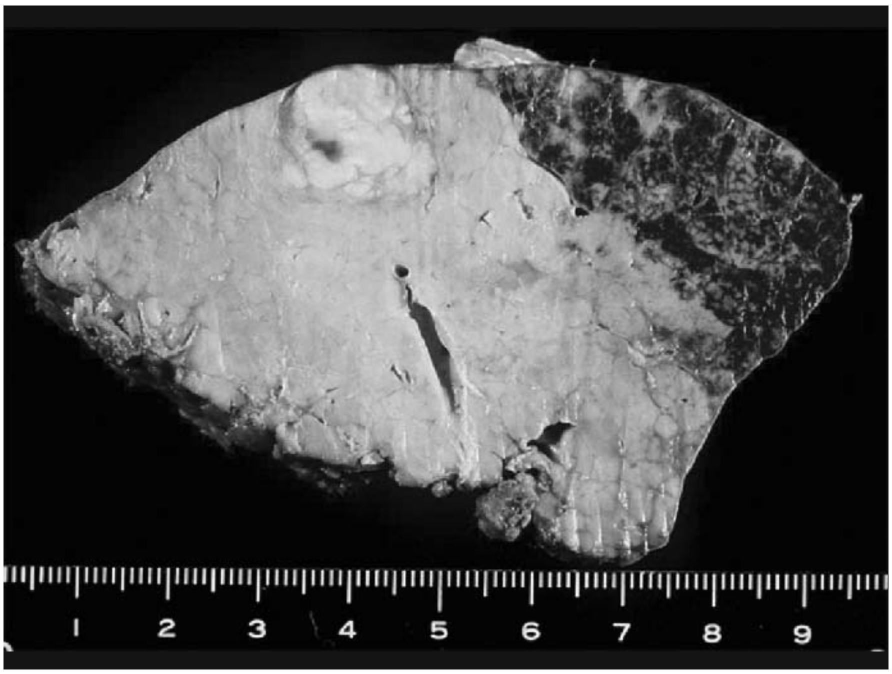


Fig. 7.5. Resected specimen of three cone units. Each cone unit is dyed with different color solution (see Fig. 34, p. 153)

Technique of Tertiary Branch Separation

Separation of the Tertiary Branch at the Right Segment

Having already placed the tape at the origin of the base of the secondary branch, pull the branch away from the liver so that an intrahepatic part of the secondary branch appears clearly. Then, peel away the liver parenchyma so that the bases of some tertiary branches are visible. However, if the right segmental branch has a long trunk, an incision of the parenchyma is required to see the bases of these tertiary branches; these bases should be taped.

The branches closest to the hilum feed the lower part of the right segment and the branches farther from the hilum feed the middle and upper parts of the right segment, with the deepest branches supplying the uppermost region of the right segment. The upper right branch(es) feed(s) the lower part of the medial area of the left segment, while the lower right branch(es) feed(s) the upper part of the medial area of the left segment as one single bundle. On clamping of the tertiary branch the area fed by this branch (a cone unit) is shown by the change of color.

Separation of the Tertiary Branch at the Middle Segment

The procedure is the same as that performed in the right segment.

When the intrahepatic part of the secondary branch is deep, an incision—about 2 cm in depth—of the surface of the parenchyma covering this secondary branch is required for a better view.

The tertiary branch(es) near the hilum feed(s) the lower part of the middle segment and those branches far from the hilum feed the middle and upper part of the middle segment.

On the clamping of one tertiary branch, the margin of the cone unit is shown by the change of color. The area that must be resected depends on the number of cone units which involve the tumor.

Separation of the Tertiary Branch at the Left Segment

The round ligament is pulled upward, and the whole length of the trunk of the left secondary branch can then be seen from the outside (this occurs in about 50% of patients). In the other 50%, the left secondary branch is covered with the liver parenchyma. The condition in which a secondary branch is hidden by the parenchyma is referred to as a parenchymal bridge (Of note, in almost 30% of individuals, the umbilical portion of the left segmental branch is covered by an umbilical bridge of liver parenchyma). As shown in Figs. 7.6 and 7.7, the main trunk of the left segmental branch is not visible.

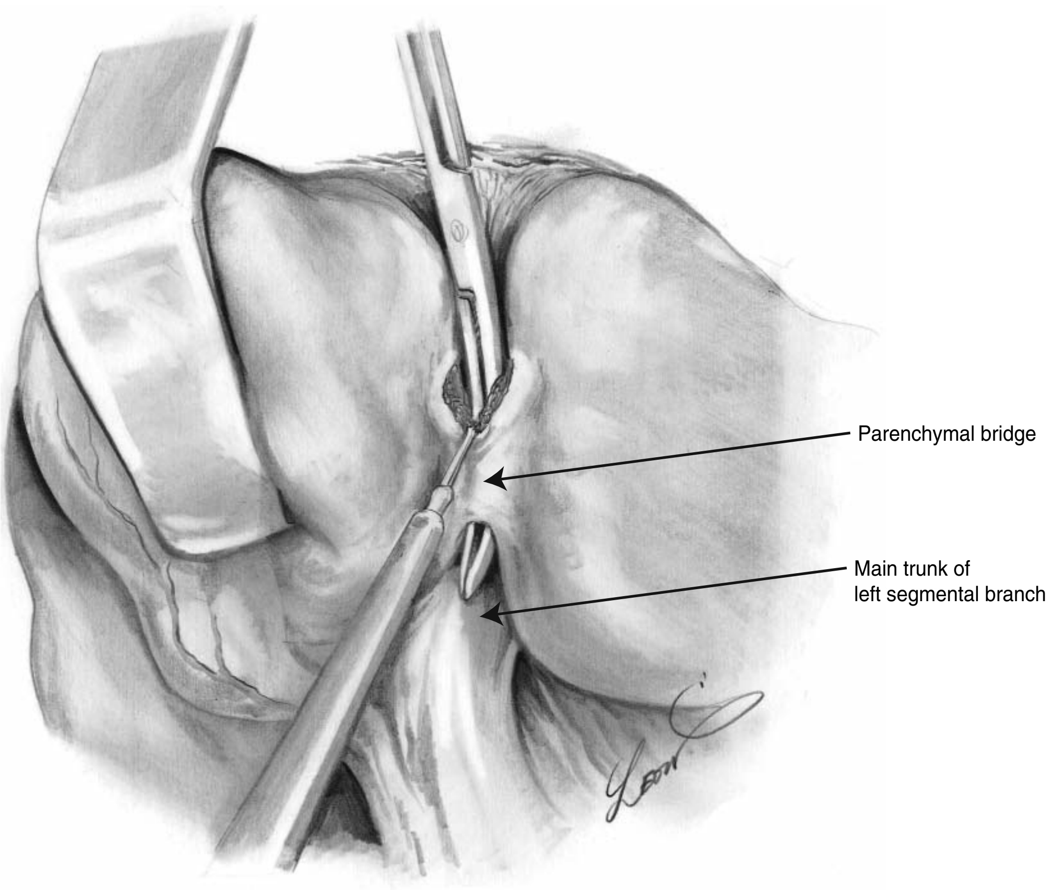


Fig. 7.6. In about 30% of cases, the main trunk of the left segment branch is covered by a thin parenchymal bridge. In these cases, this must be opened using an electric coagulator

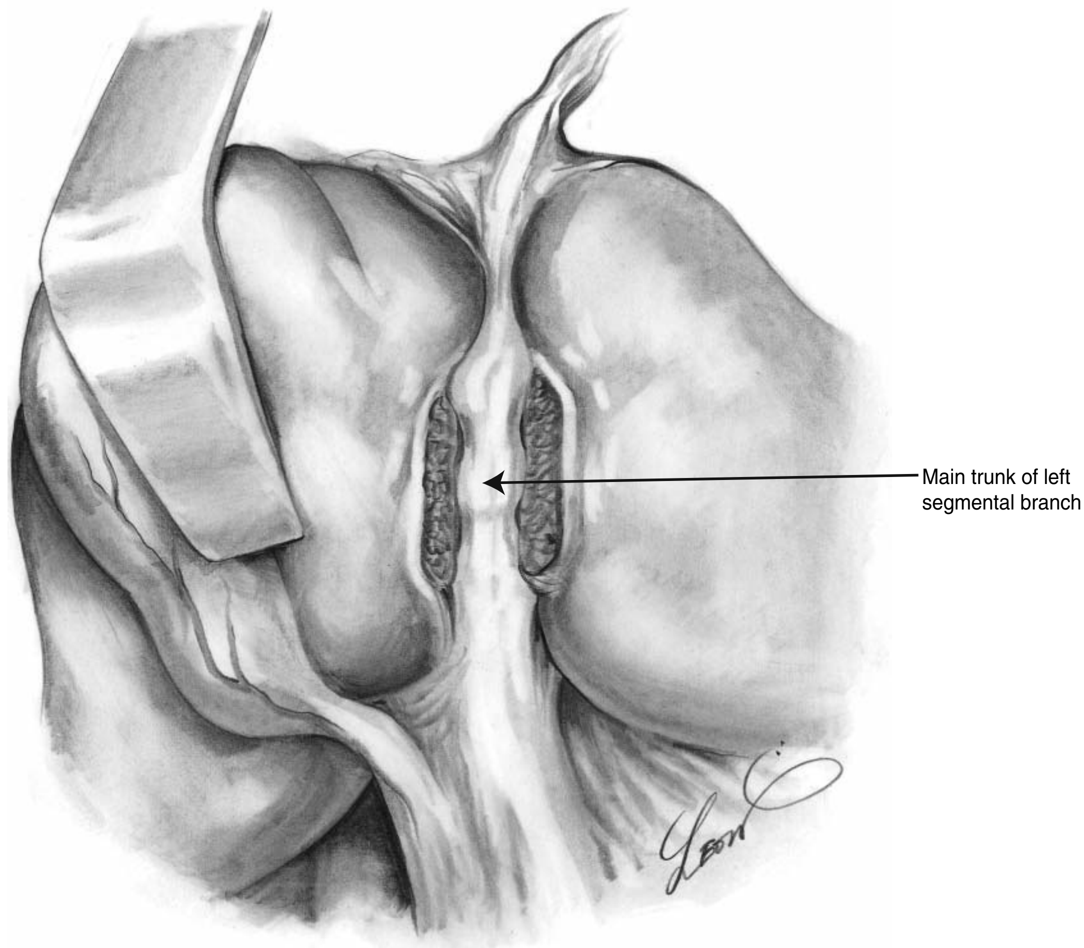


Fig. 7.7. After cutting the parenchymal bridge, the main trunk of the left segmental branch can be seen

The back of the parenchymal bridge is not fixed to a Glissonean pedicle, and therefore the bridge can easily be transected and opened.

The upper left branch(es) feed(s) the lower part of the left lateral area of the left segment, while the lower left branch(es) nourish(es) the upper part of the left lateral area of the left segment.

Resection of the Left Lateral Inferior Area (Couinaud's S3)

This procedure—an example of a one-cone-unit resection—is indicated for small tumors in the lower left lateral part of the liver (Fig. 7.8).

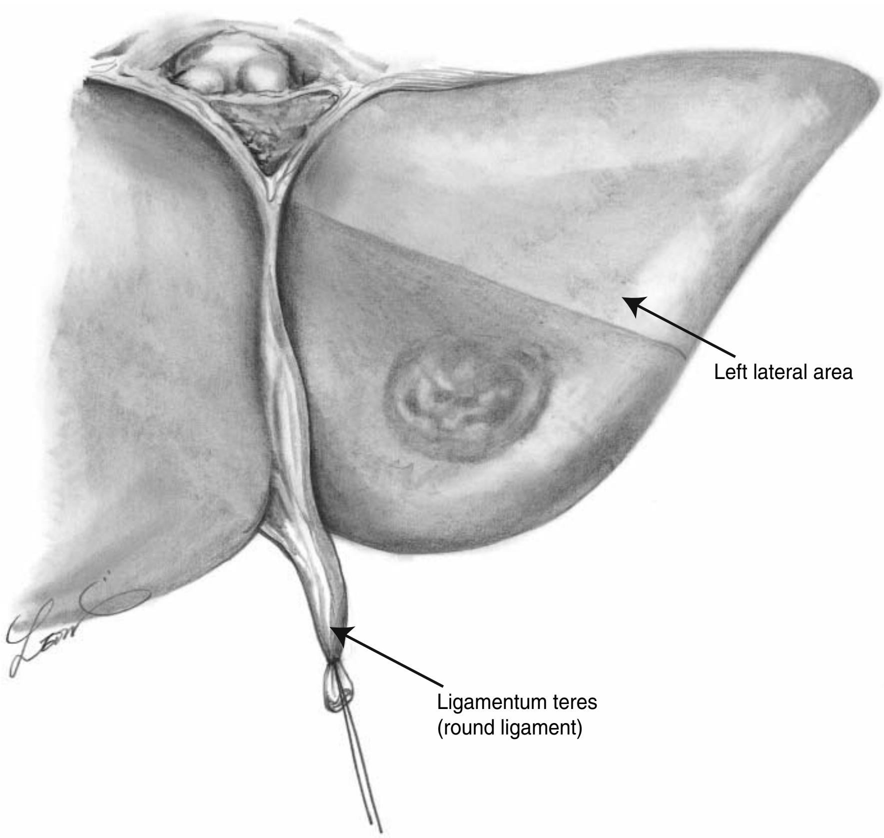


Fig. 7.8. Left lateral inferior area resection

The round ligament is pulled upward to expose the umbilical portion en face. Detach the upper left side of the left segmental branch from the surrounding liver parenchyma to place a tertiary branch bifurcating from the umbilical portion in full view. This pedicle is that of the tertiary branches of Couinaud's S3 (Fig. 7.9). Figure 7.10 shows the demarcated S3 area from an abdominal view. The liver parenchyma is dissected on the demarcated line; the left hepatic vein is exposed on the cut surface (Fig. 7.11).

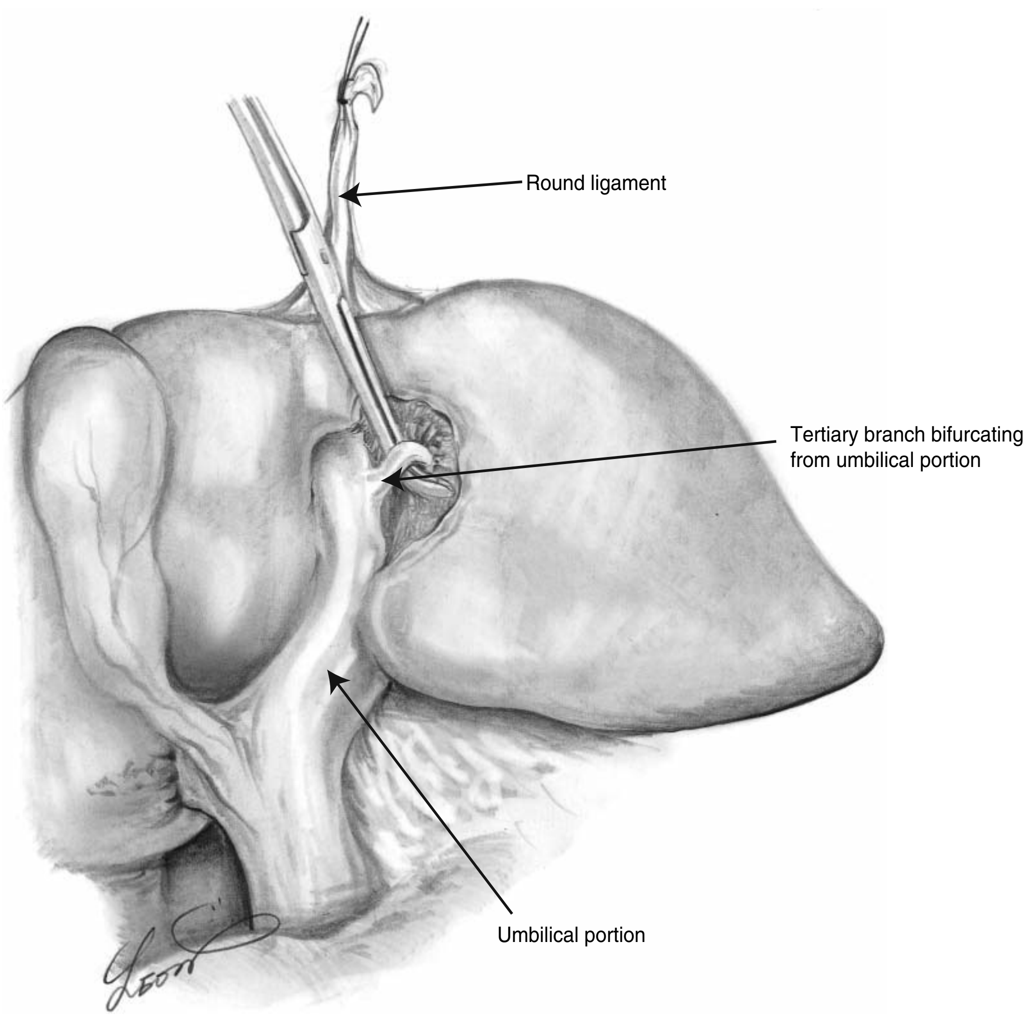
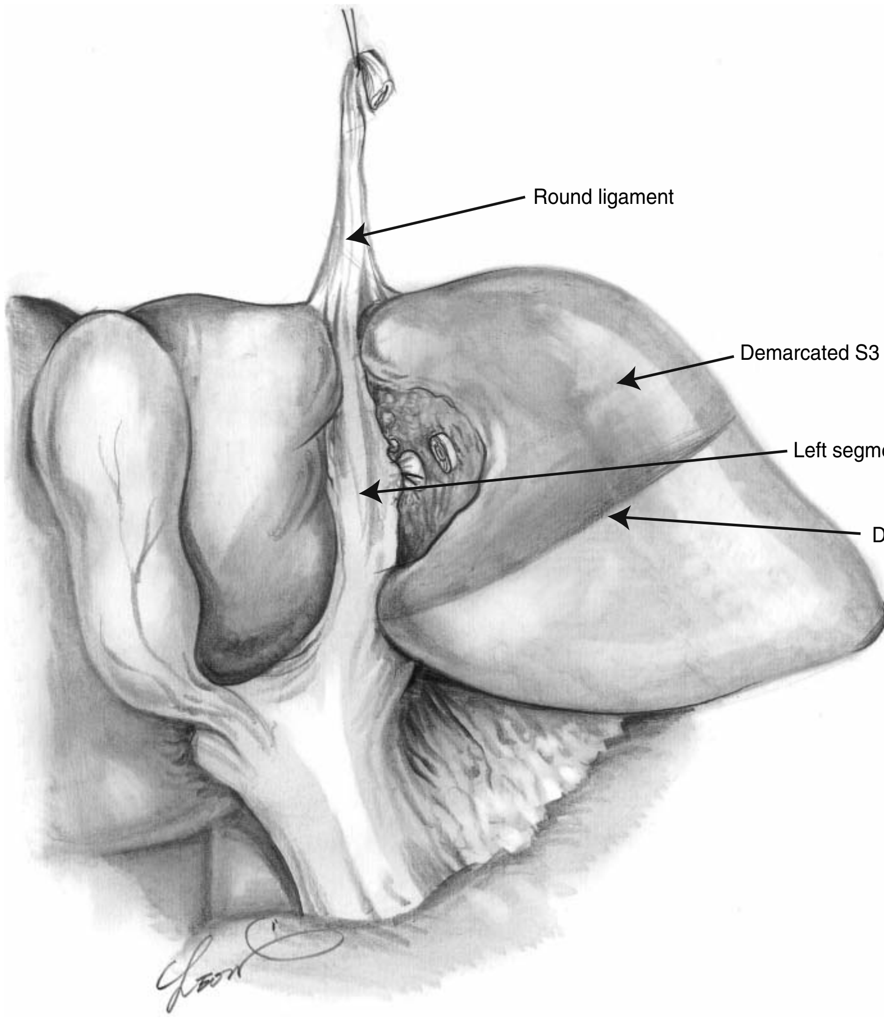


Fig. 7.9. Detachment of the left side of surrounding liver parenchyma from left segmental pedicle. There are 1–2 tertiary branches

Fig. 7.10. Demarcated S3 area—abdominal view



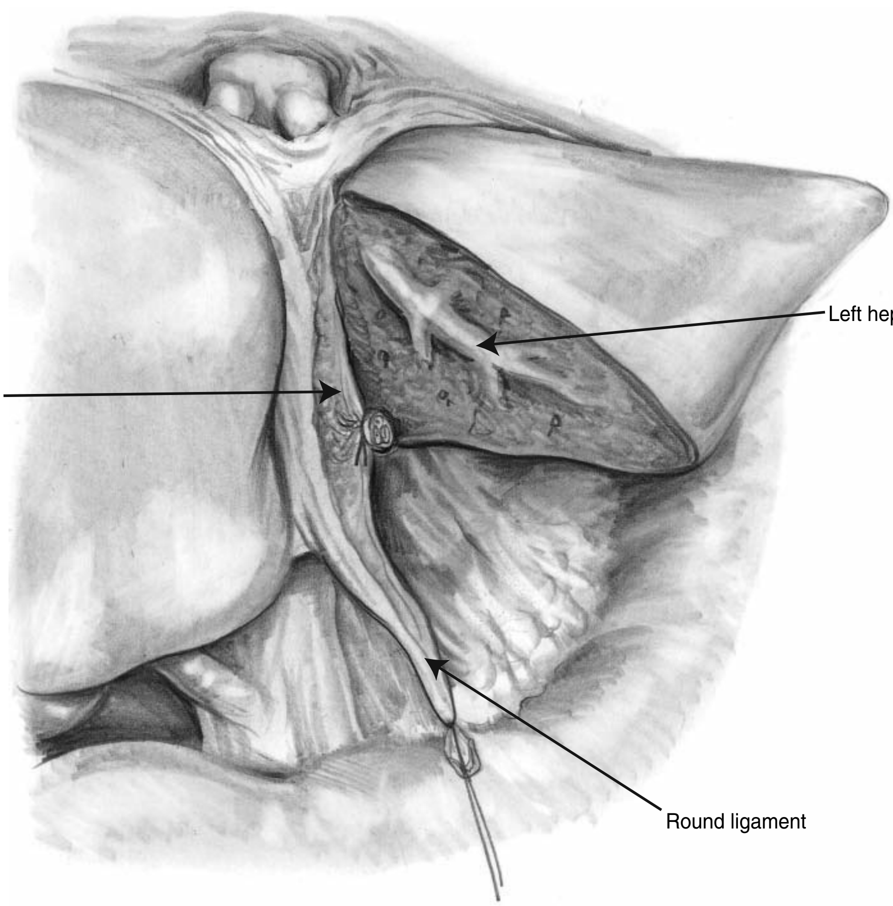


Fig. 7.11. Left lateral inferior area resection is completed

Resection of the Lateral Inferior and the Medial Inferior Areas of the Left Segment (Couinaud's S3 plus Lower Part of S4) (See DVD 2)

This procedure (Figs. 7.12 and 7.13) is indicated for small tumors located just under the falciform ligament.

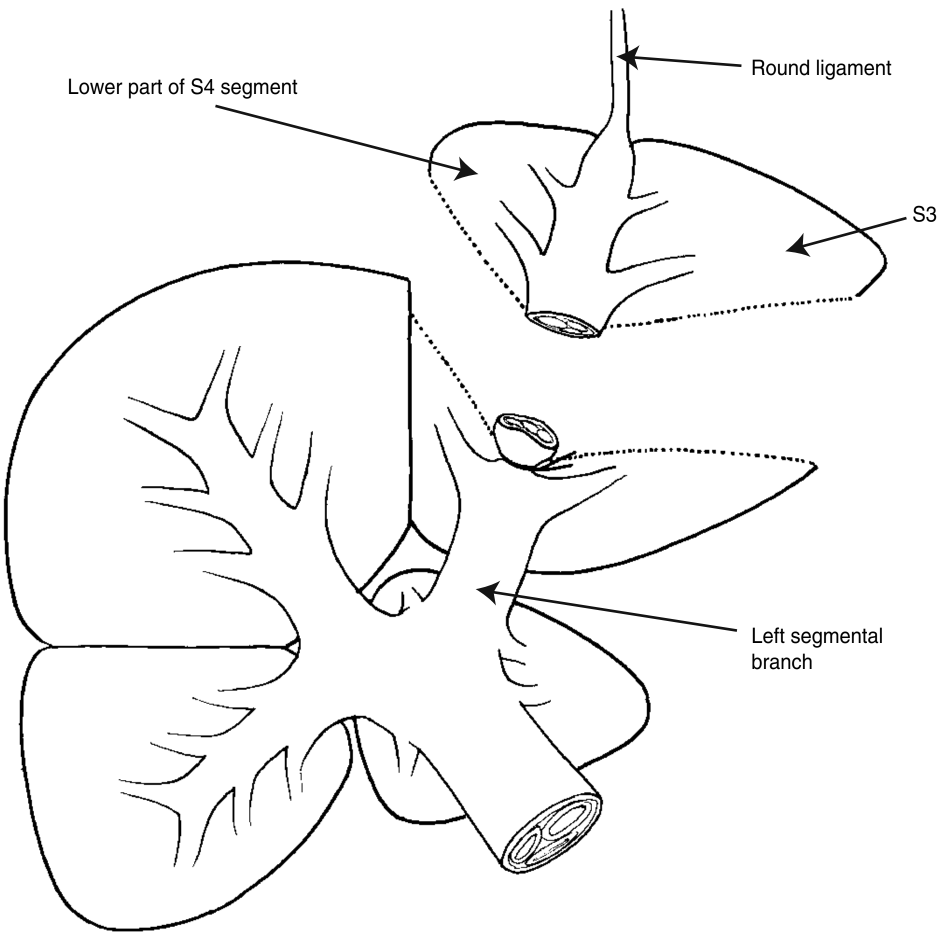


Fig. 7.12. Schema of resection of Couinaud's S3 plus lower part of S4

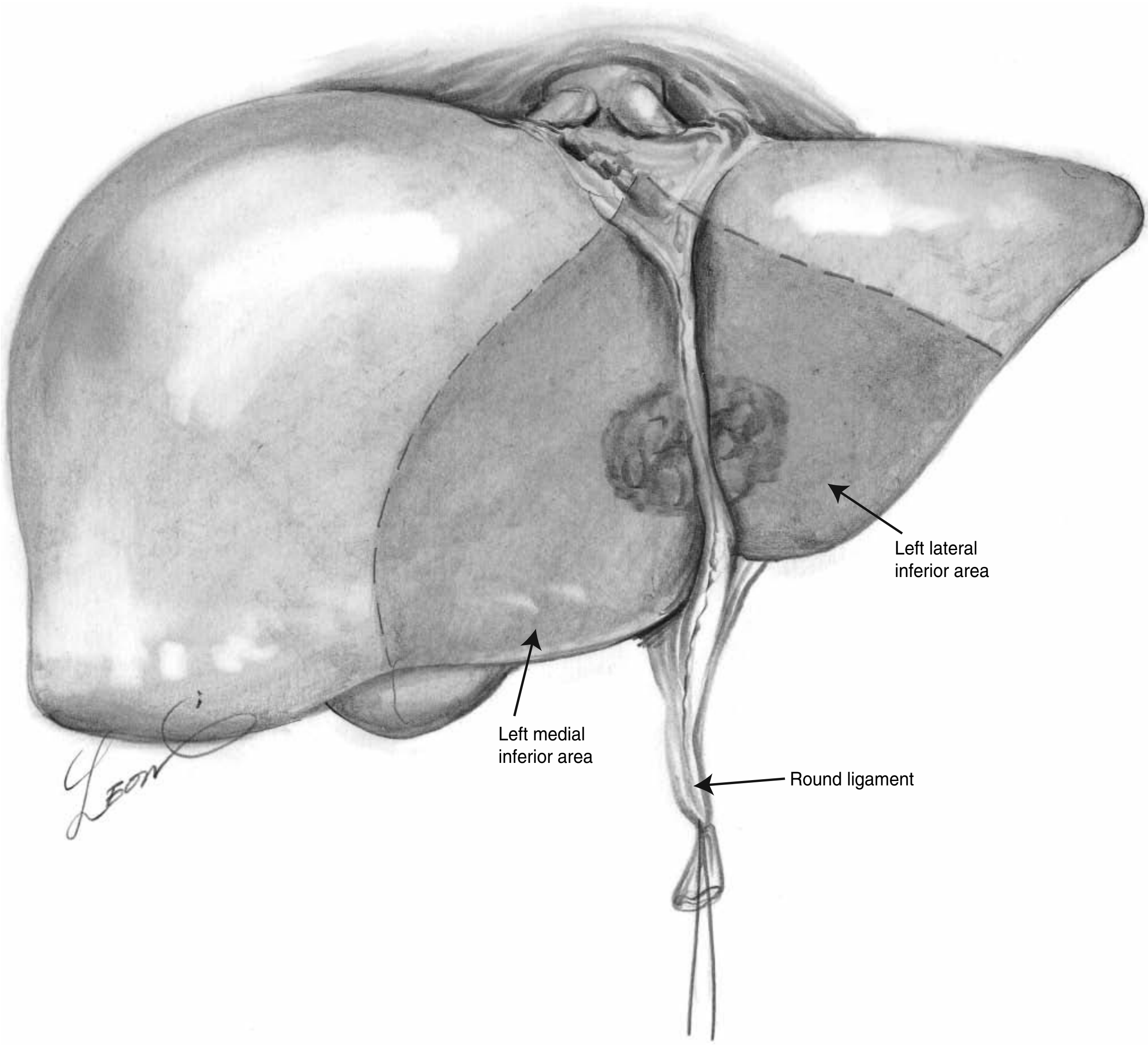


Fig. 7.13. Small tumor is located just under the falciform ligament

In this procedure, the left segmental branch is transected at the middle part of the trunk; this resection corresponds to an S8 resection. The left segmental branch is detached circumferentially from the liver parenchyma at its midpoint to free it from its surroundings, and it is then ligated and cut (Figs. 7.14 and 7.15).

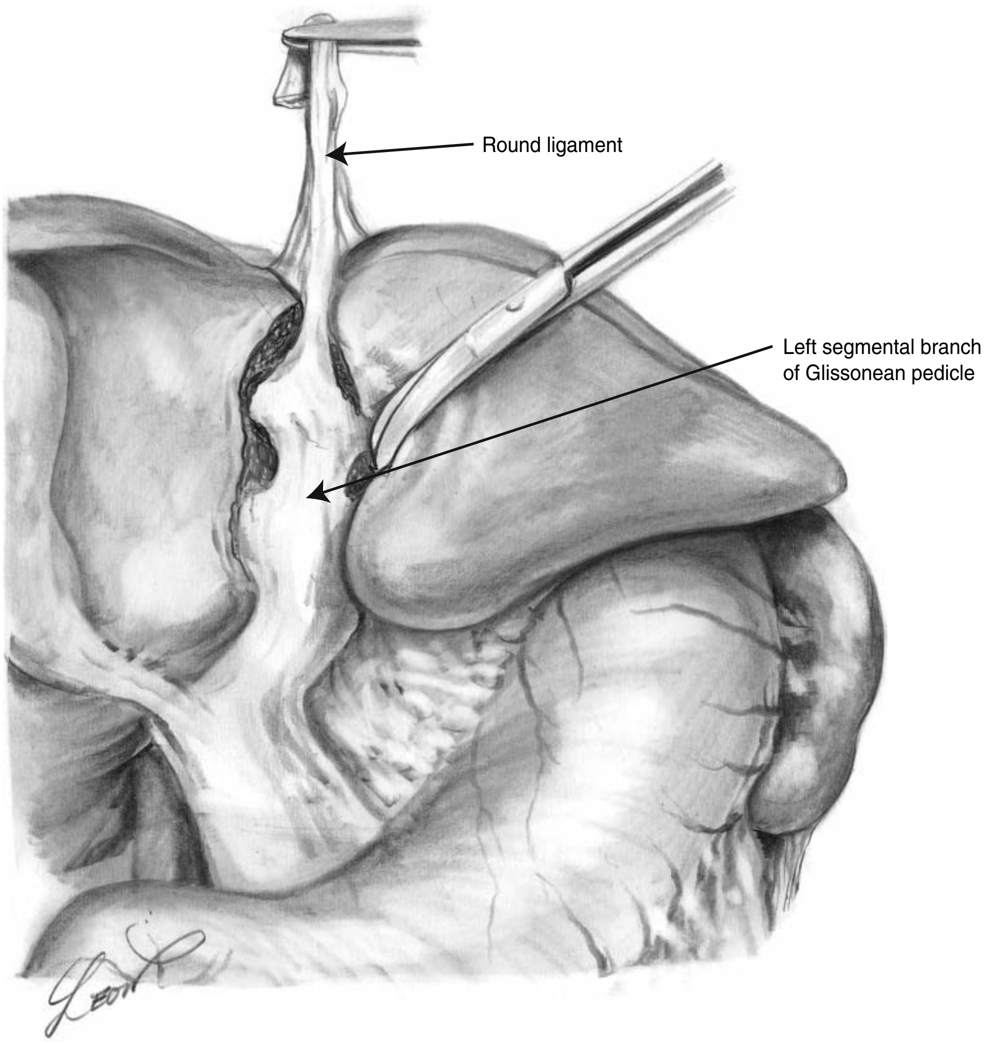


Fig. 7.14. Round ligament is lifted up. Middle part of left segmental branch is dissected from liver parenchyma

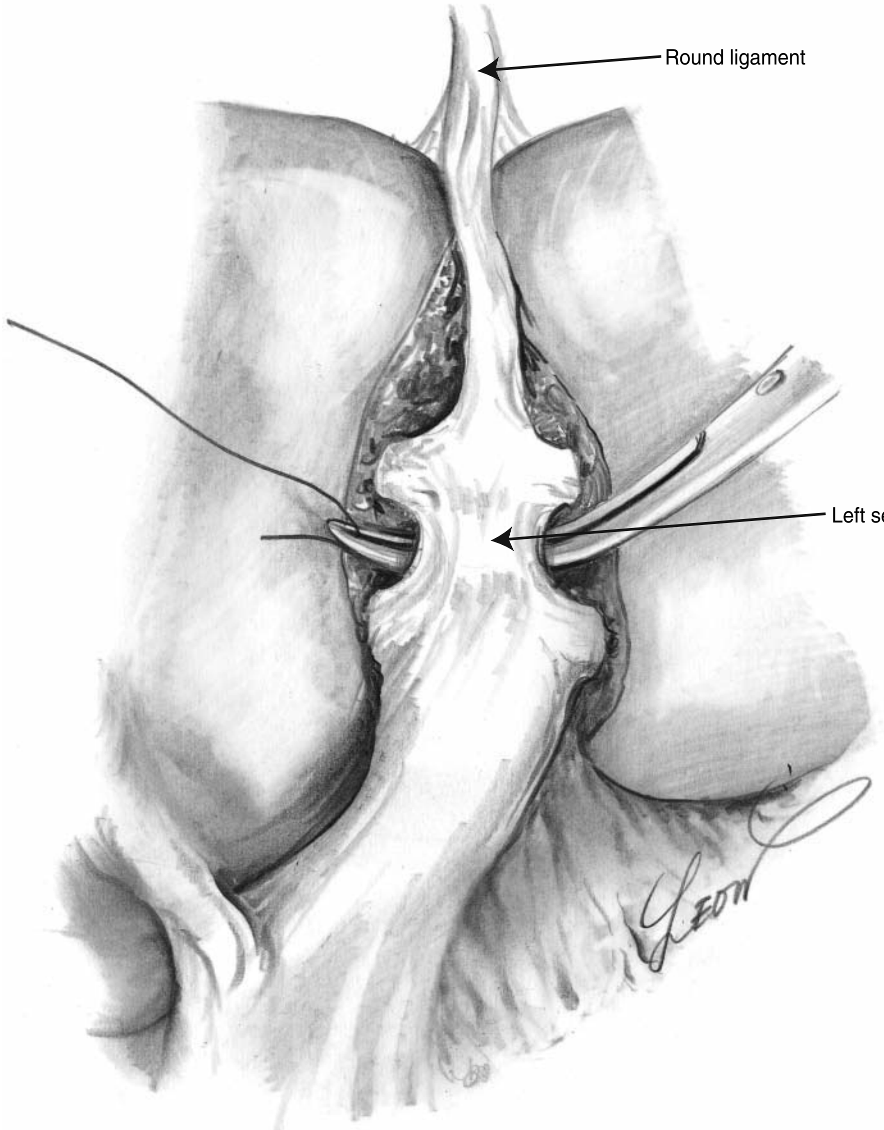


Fig. 7.15. Ligature at the middle portion of left segmental branch

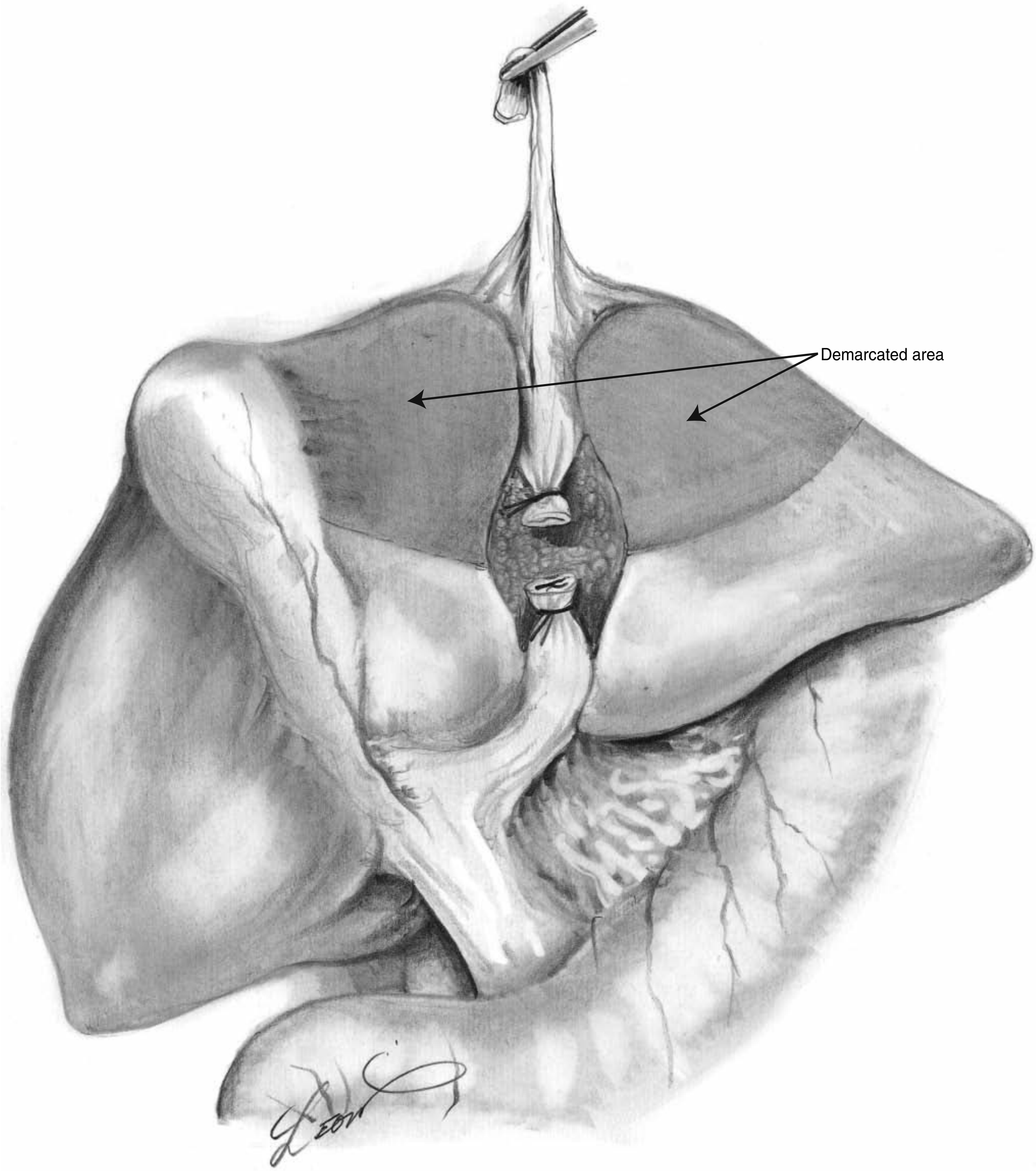


Fig. 7.16. Demarcated area—abdominal view

Figure 7.16 shows the demarcated area from an abdominal view and Fig. 7.17 shows the completed resection. The cut stump of the left segmental branch is visible at the apex of the triangular-shaped space after resection. The S2 and upper part of the S4 areas remain.

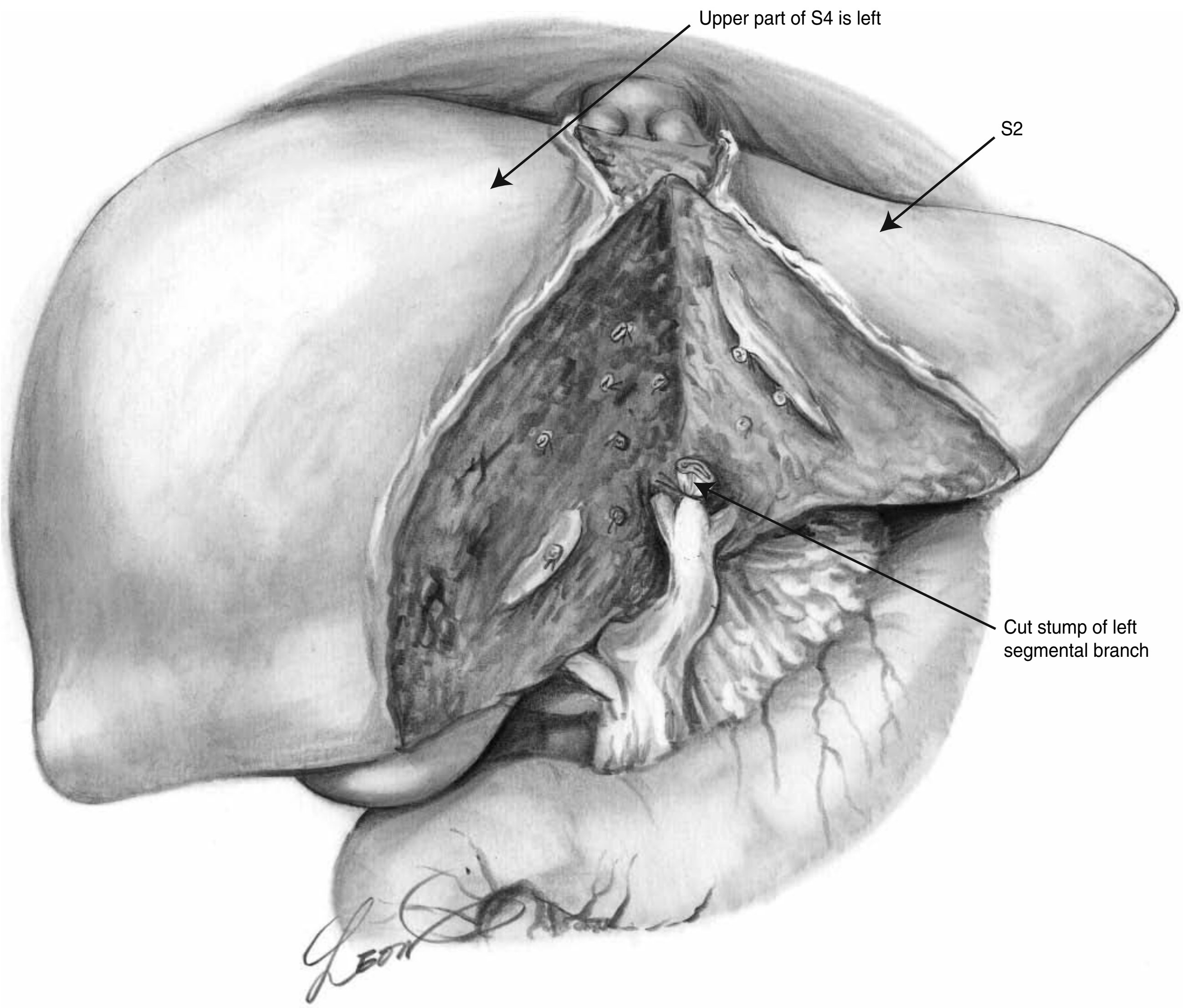


Fig. 7.17. Completed resection

Resection of the Medial Area of the Left Segment (Couinaud's S4)

The left medial area of the left segment is fed by some tertiary branches which arise from the left part of the umbilical portion of the Glissonean pedicle (Figs. 7.18 and 7.19). The round ligament is pulled upward. Then the umbilical portion is seen en face. The upper right side of the umbilical portion of the Glissonean pedicle is torn from the surrounding liver tissue. Several tertiary branches come into view, and these must be transected one by one (Fig. 7.20a–d).

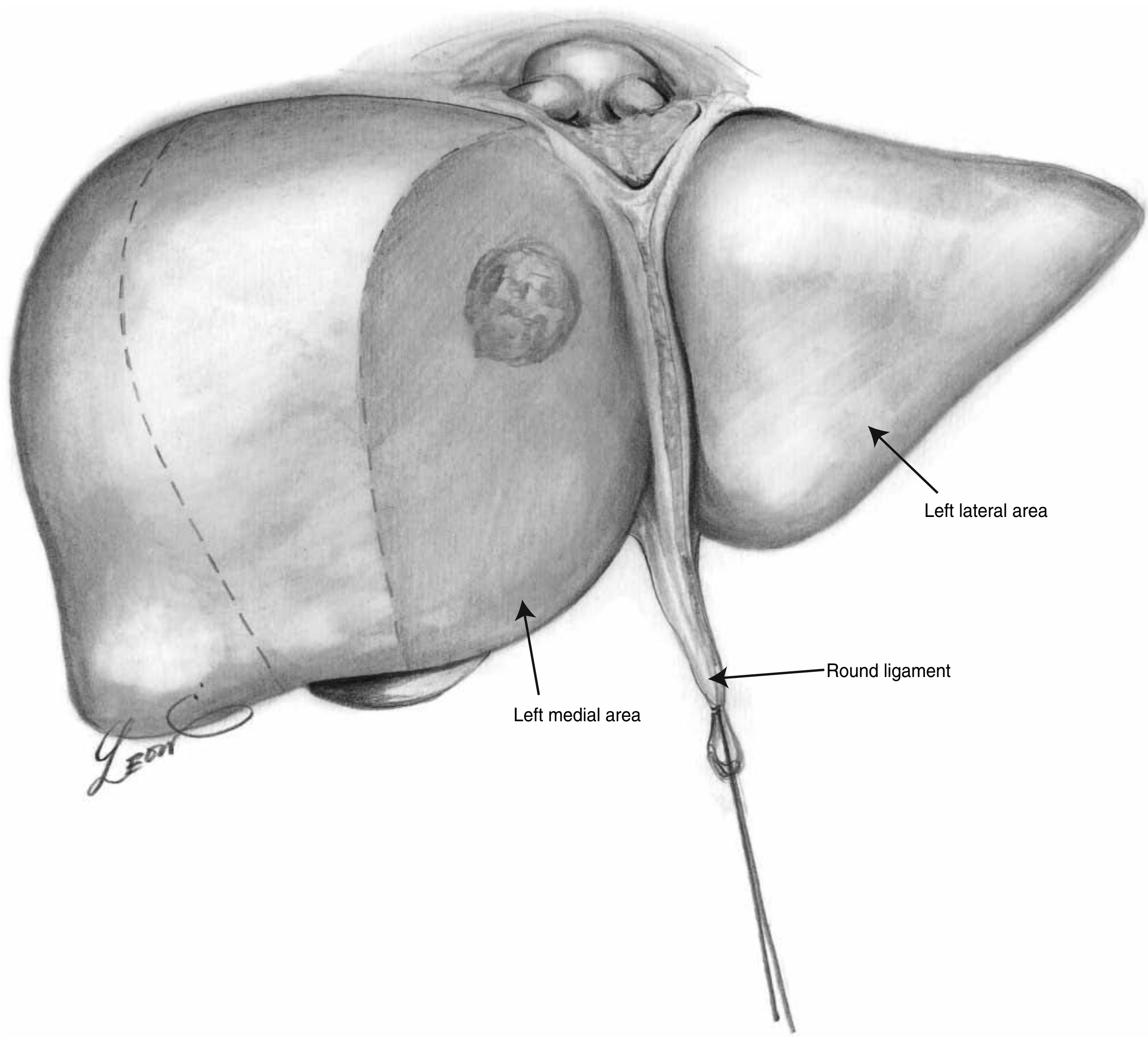


Fig. 7.18. Resection of Couinaud's S4 (left medial area of left segment)

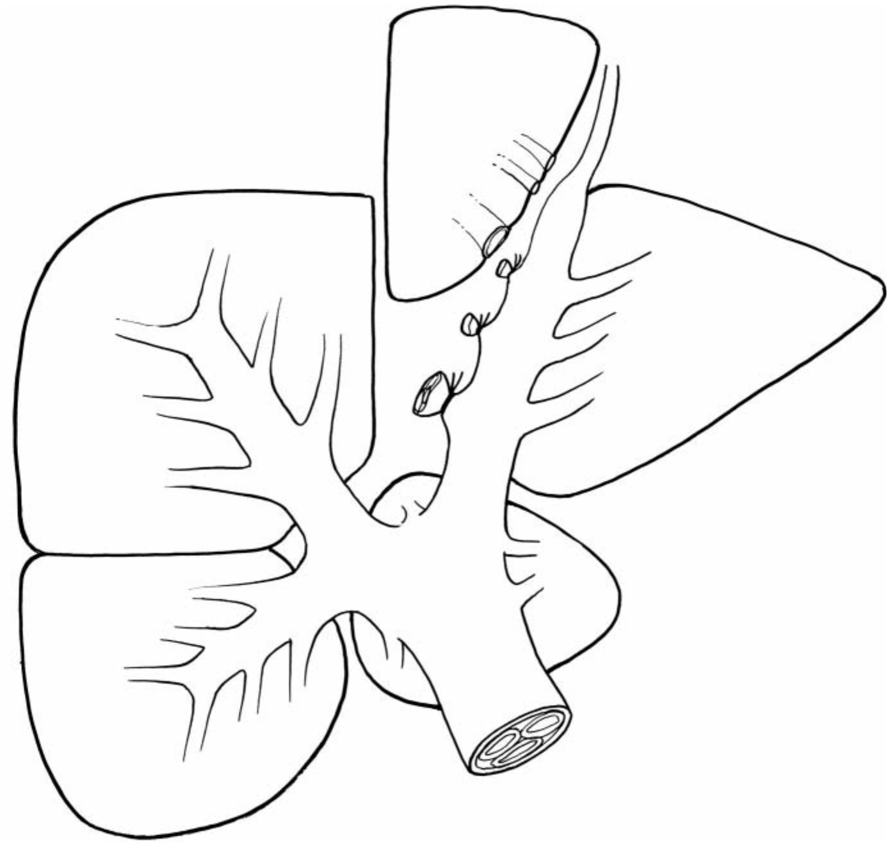
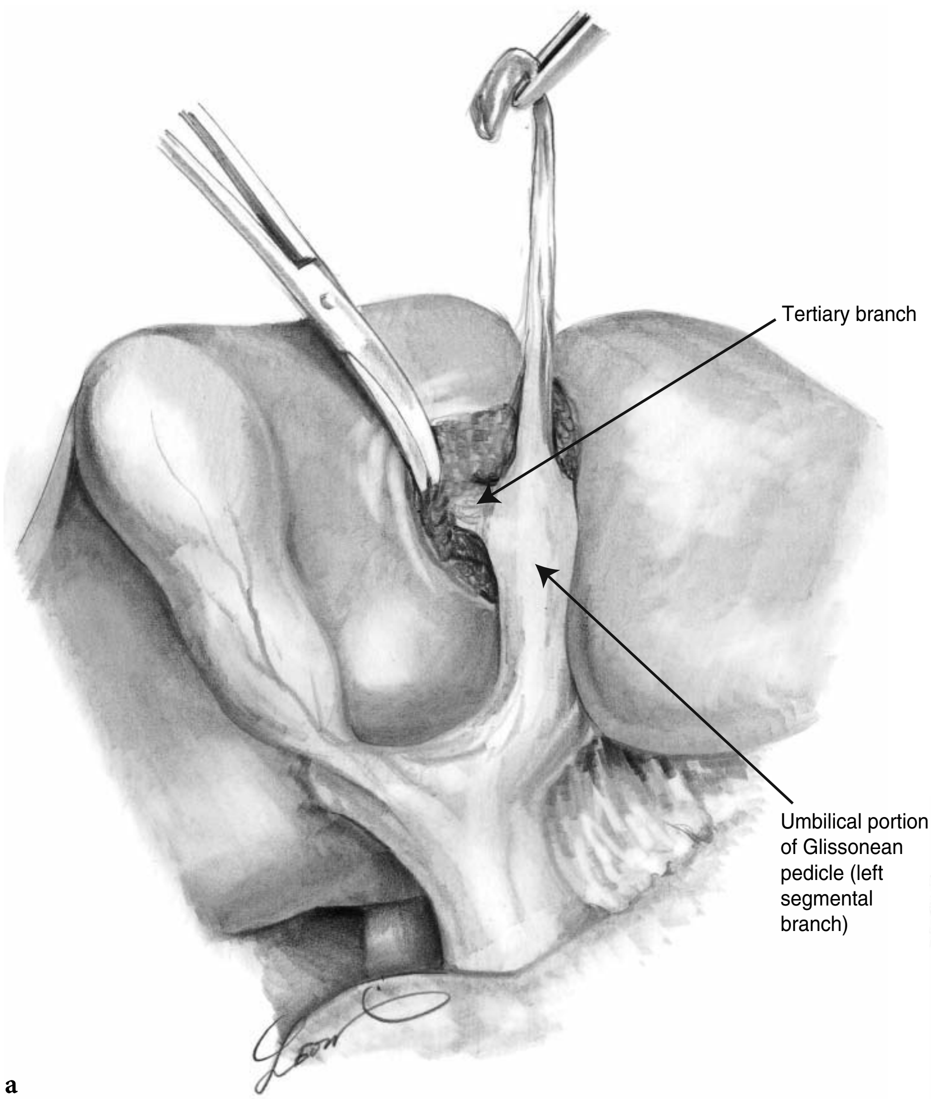
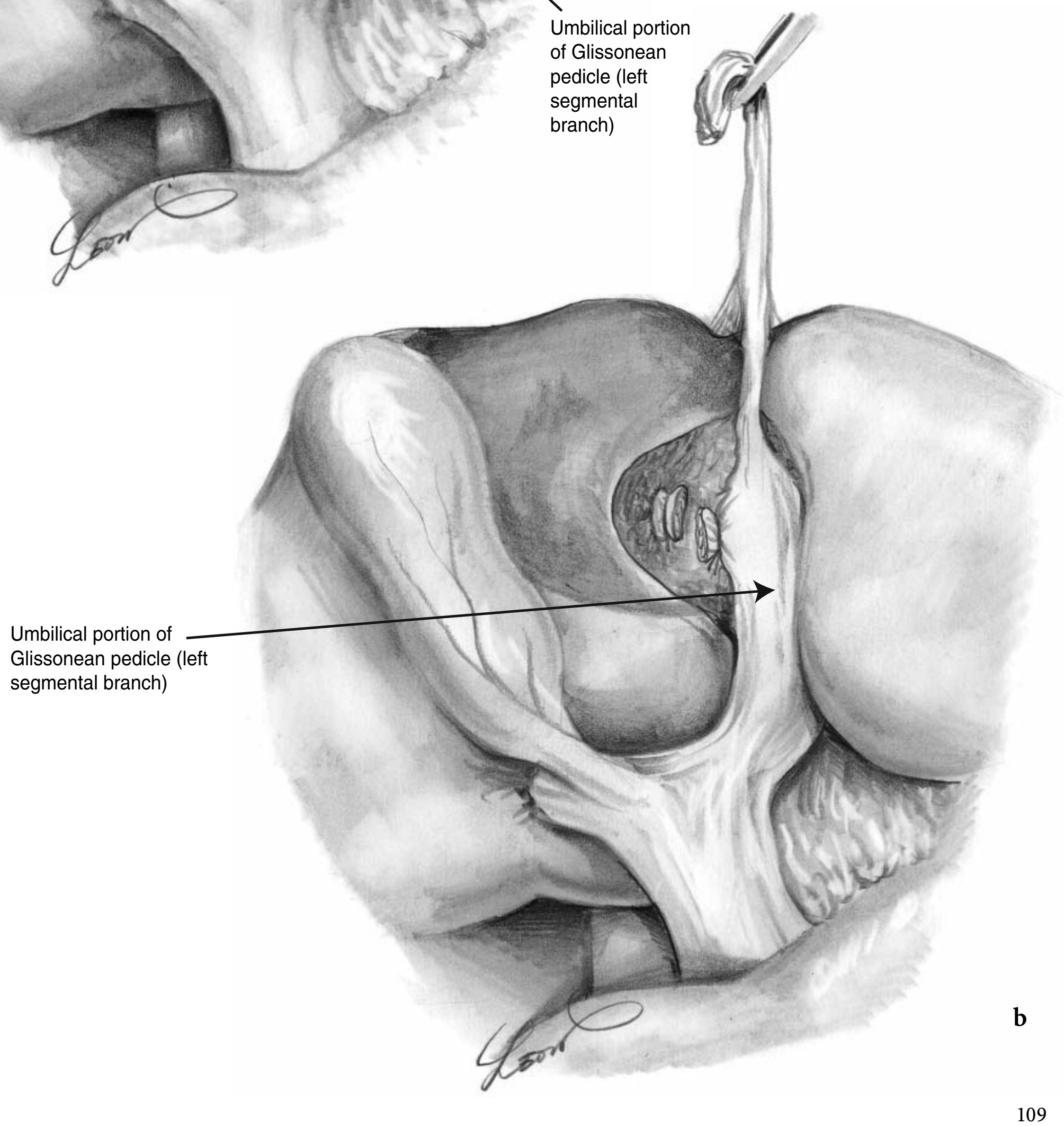


Fig. 7.19. Schema of resection of Couinaud's S4 (left medial area of left segment)

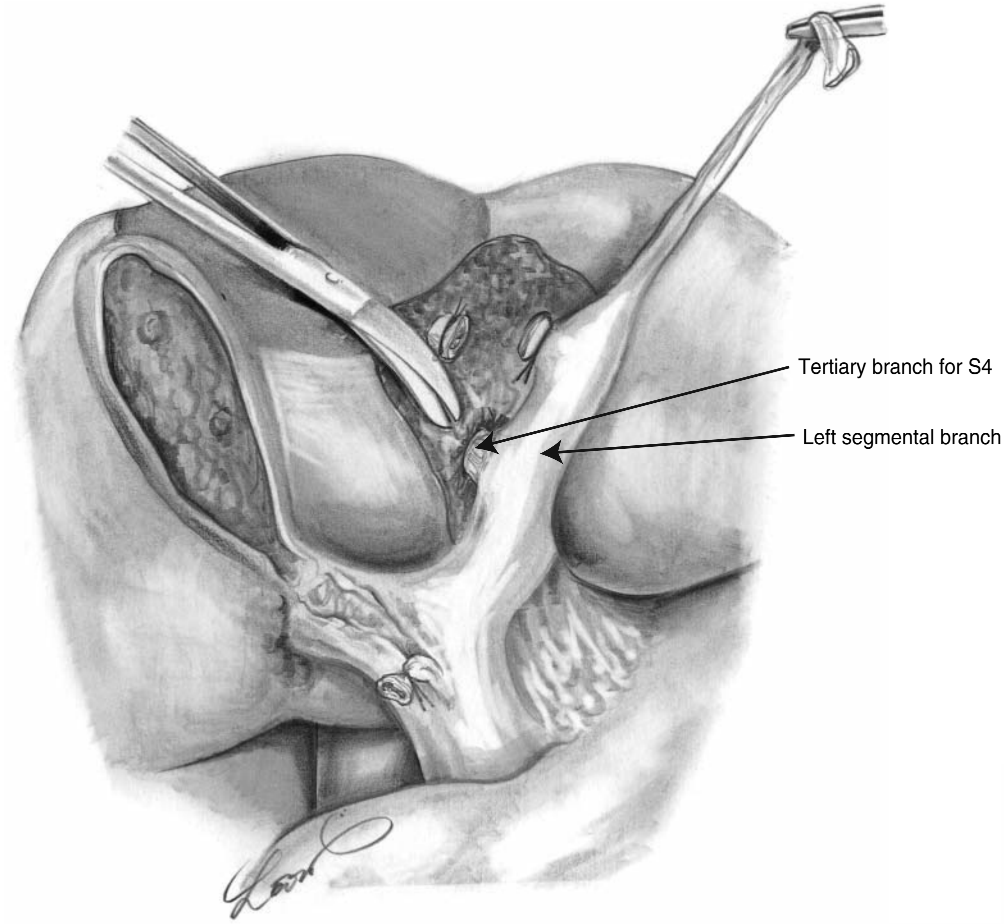
Fig. 7.20a–d. Detachment of the right side of the surrounding liver parenchyma. There are a number of tertiary branches



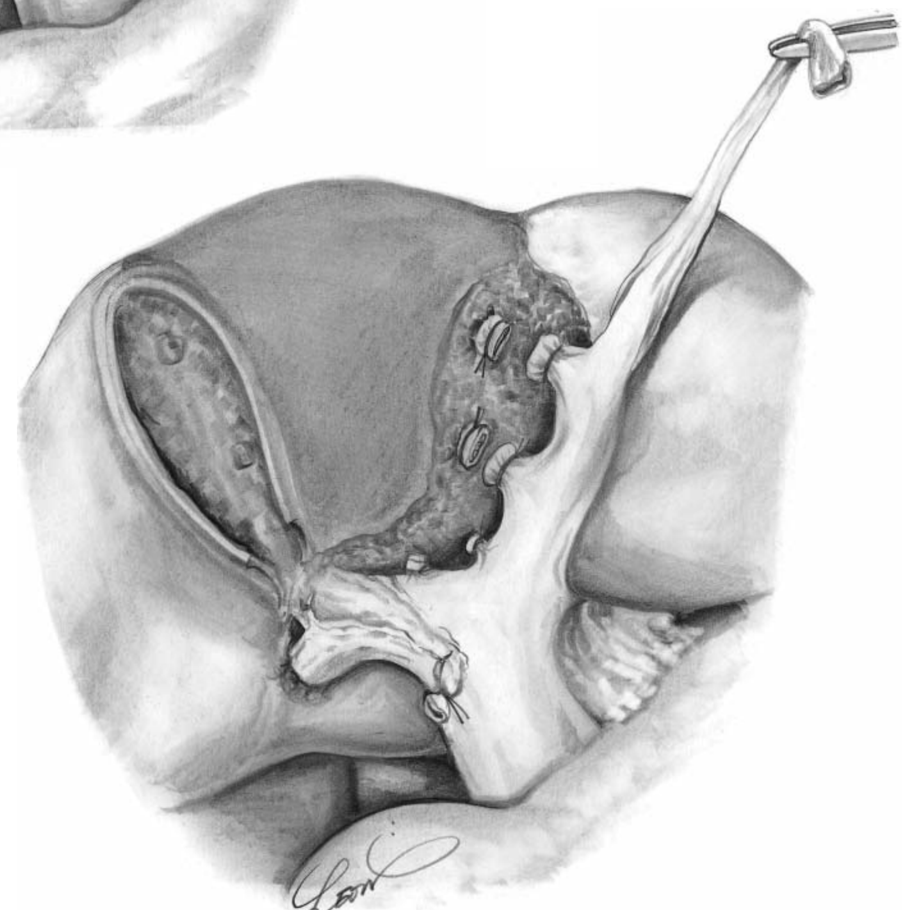
a



b



c



d

Fig. 7.20. *Continued*

Dissection of the border of the medial segment (Fig. 7.21) is done in just the same way as that done in left segmentectomy. After ligation of the tertiary branches which feed the medial segment, the true border will be recognized by the change of color of the parenchyma. Dissection is performed along the two demarcated planes shown in Fig. 7.22a–c. The border of the caudate area is dissected on the plane of the paracaval triangle.

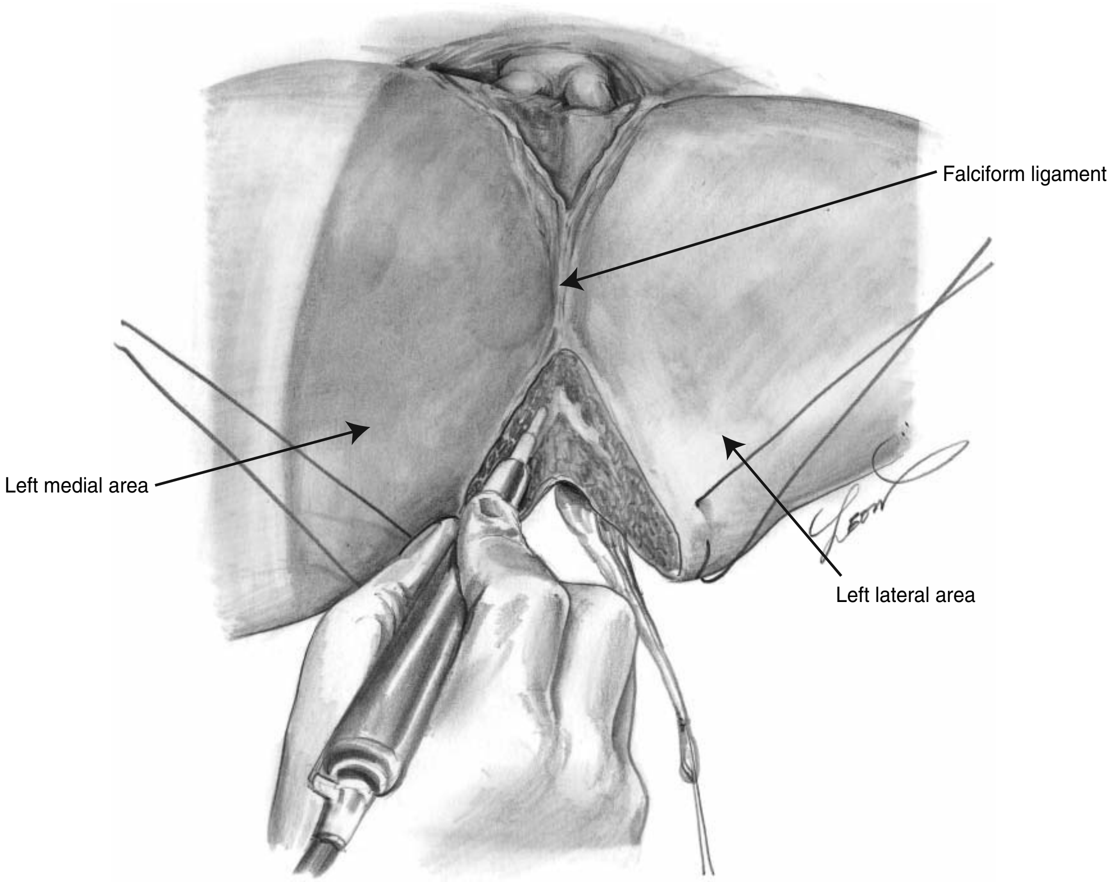


Fig. 7.21. Dissection of border of medial segment

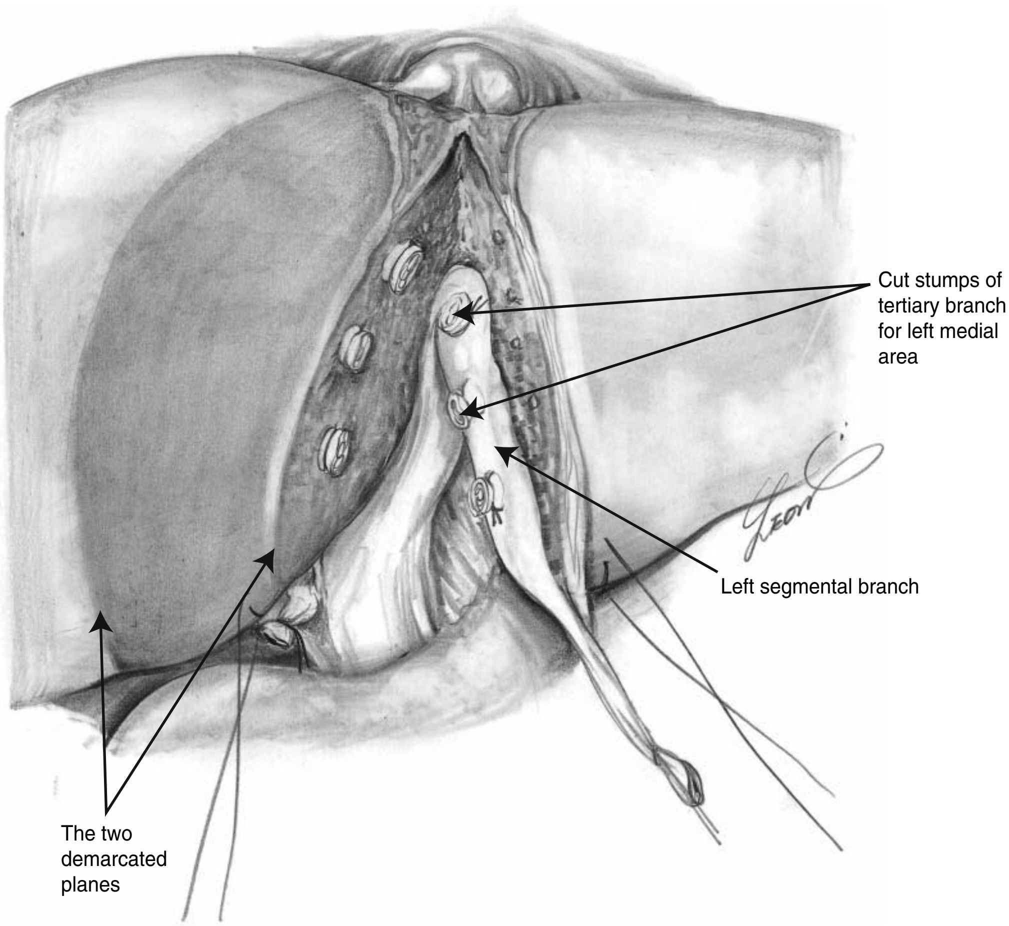
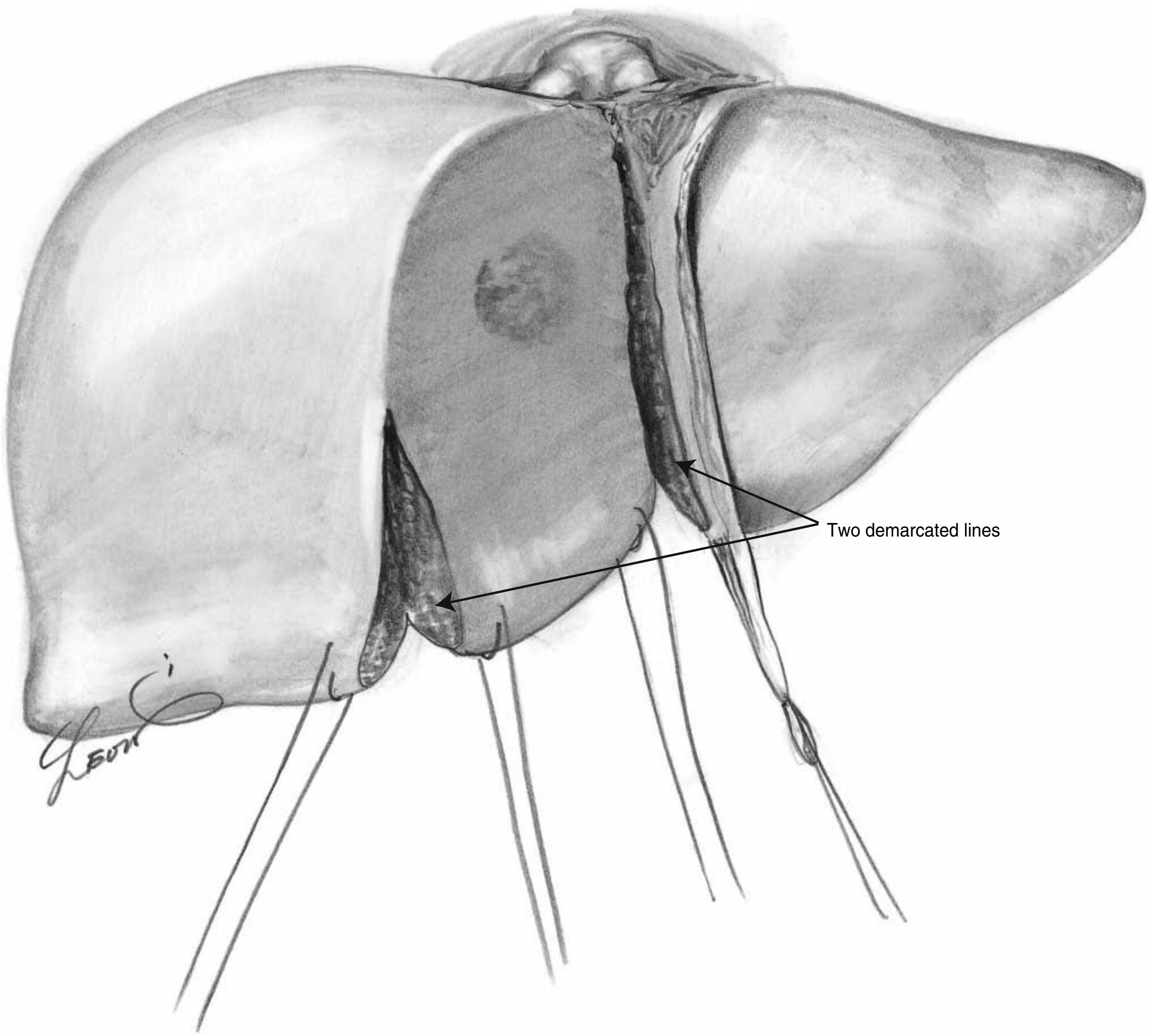
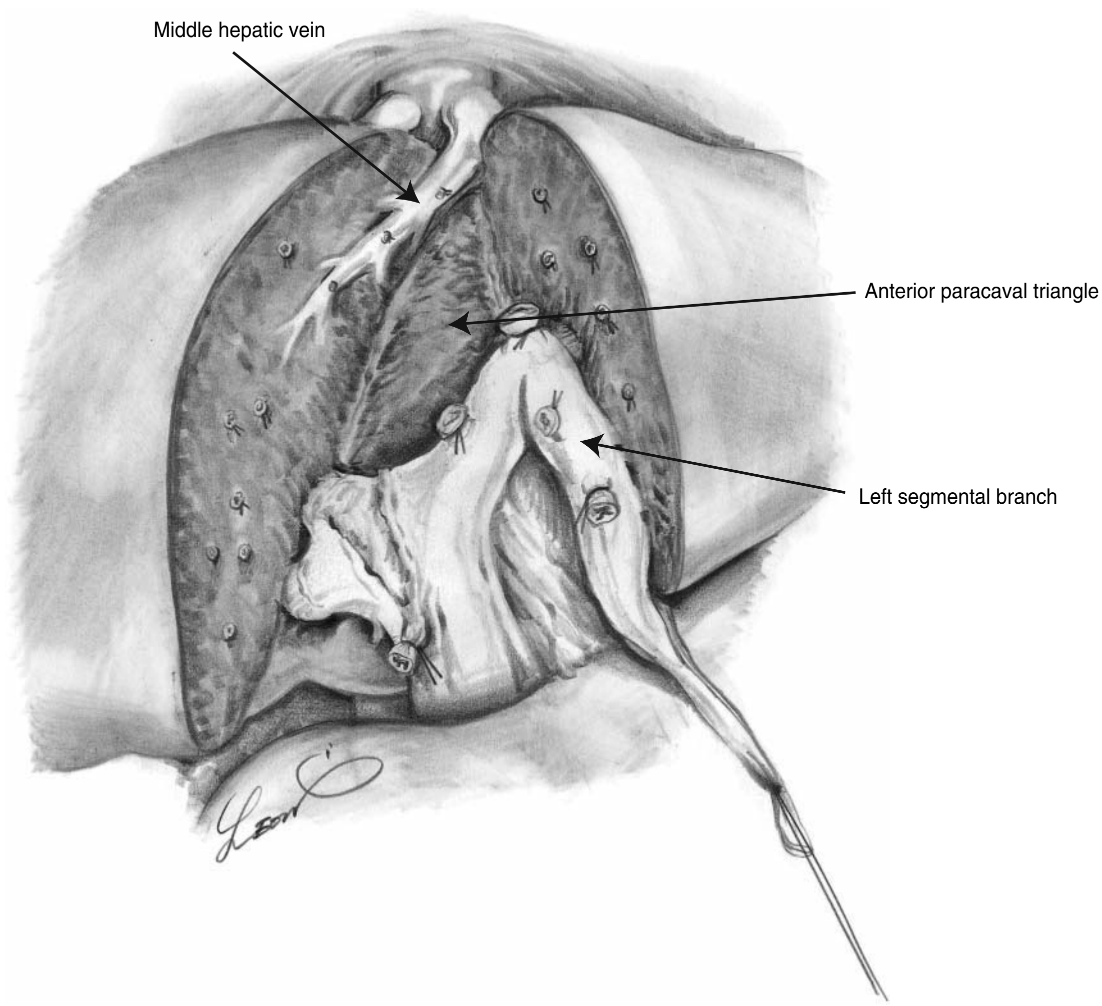


Fig. 7.22a. Dissection on left demarcated plane is performed



b

Fig. 7.22b. Dissection on right side line of demarcated area



c

Fig. 7.22c. Medial area of the left segment resection is completed

Resection of the Lateral Area of the Left Segment (See DVD 2)

This resection consists of the transection of several Glissonean pedicles ramifying from the left side of the left segmental branch of the Glissonean pedicle, and the dissection of the liver along the line of attachment of the falciform ligament (Fig. 7.23).

All of the Glissonean pedicles that flow into the lateral area of the left segment branch from the left side of the umbilical portion. The round ligament is detached from the abdominal wall and pulled upward to expose the umbilical portion en face.

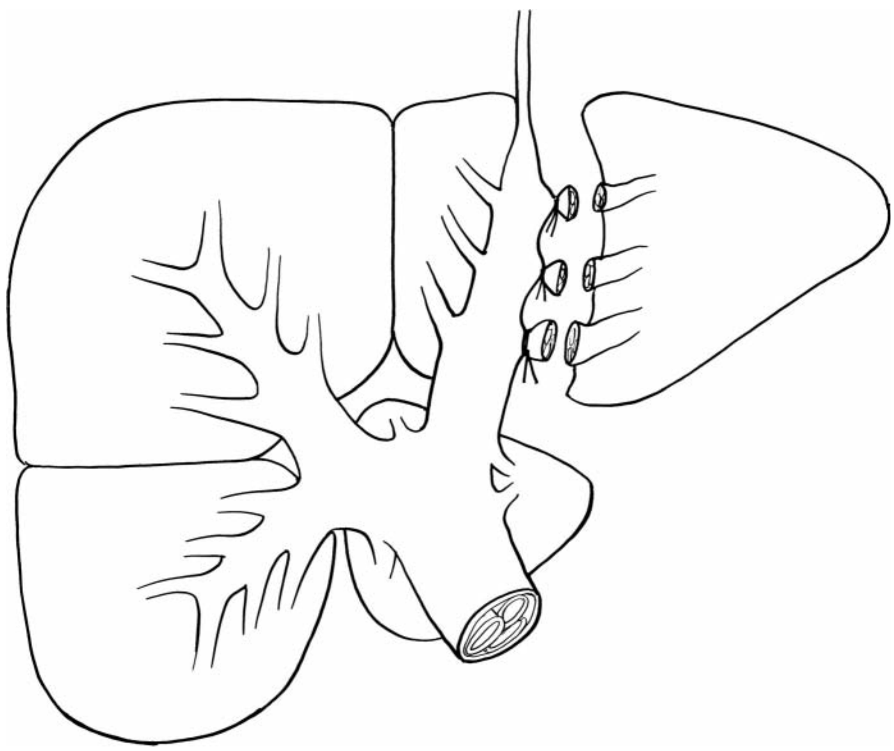
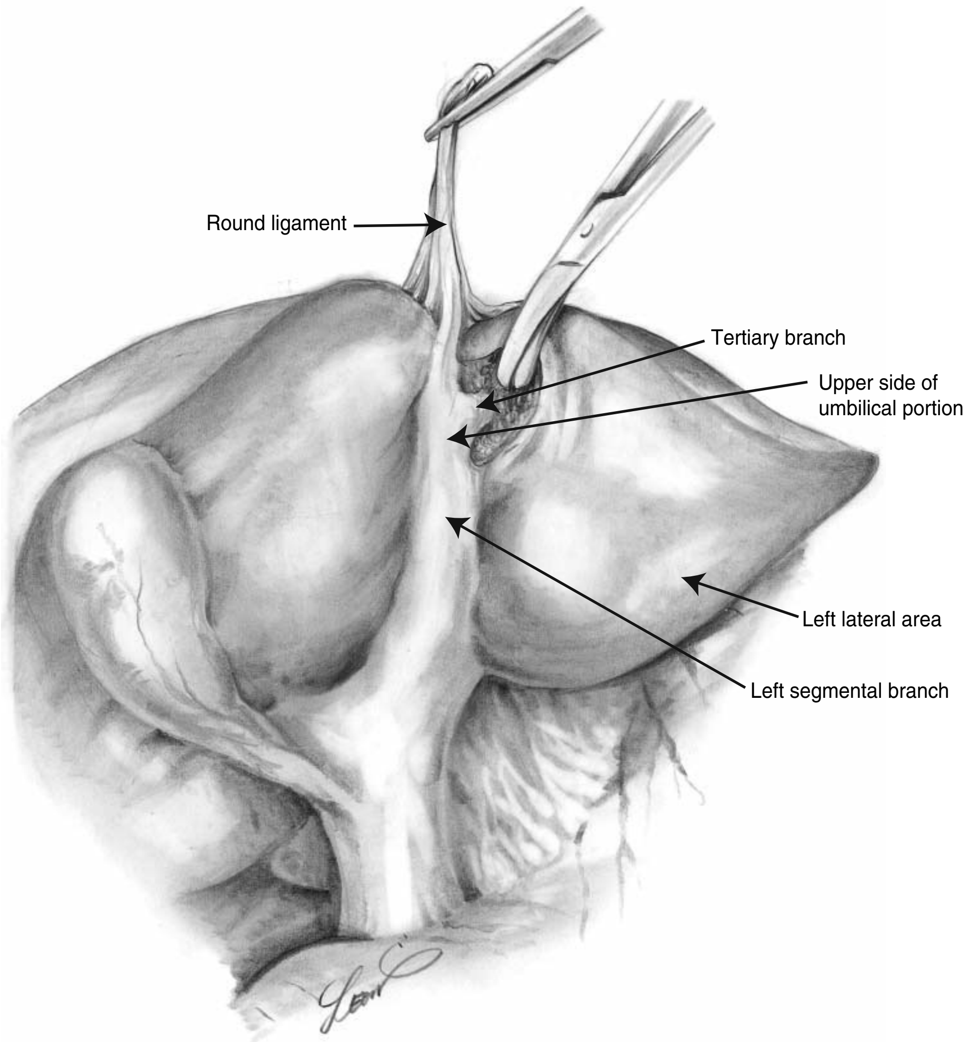


Fig. 7.23. Schema of resection of lateral area of left segment

As shown in Fig. 7.24a–f, when proceeding with the dissection of the liver parenchyma around the upper side of the umbilical portion, a tertiary branch coming from the umbilical portion will be in full view. This pedicle is that of the tertiary branch of Couinaud's S3. Several of these tertiary branches must be ligated and cut, one after another.

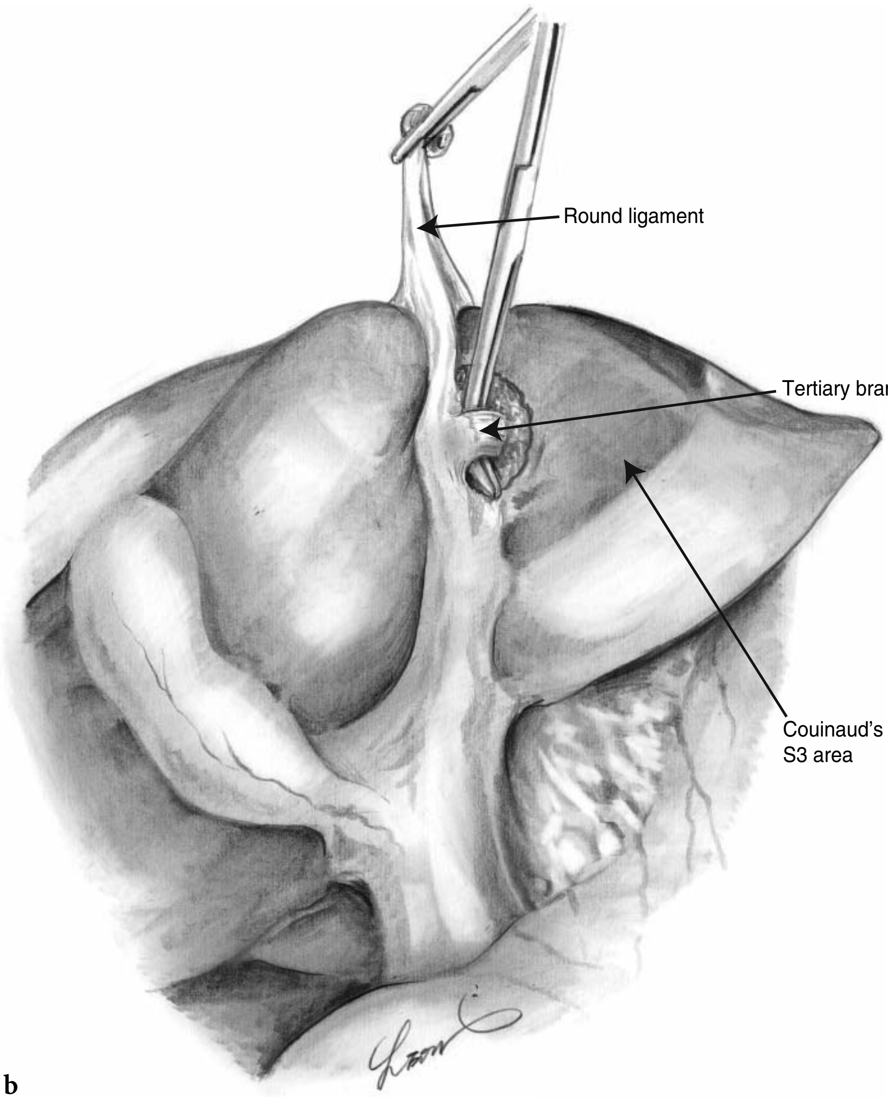
The tertiary branches near the round ligament feed the inferior part of the left lateral segment, while the branches near the hilum feed the superior part of the left lateral segment.



a

Fig. 7.24a. Dissection of liver parenchyma around upper side of umbilical portion

Fig. 7.24b. Tertiary branch to the lateral area is ramified from left side of left segmental pedicle



b

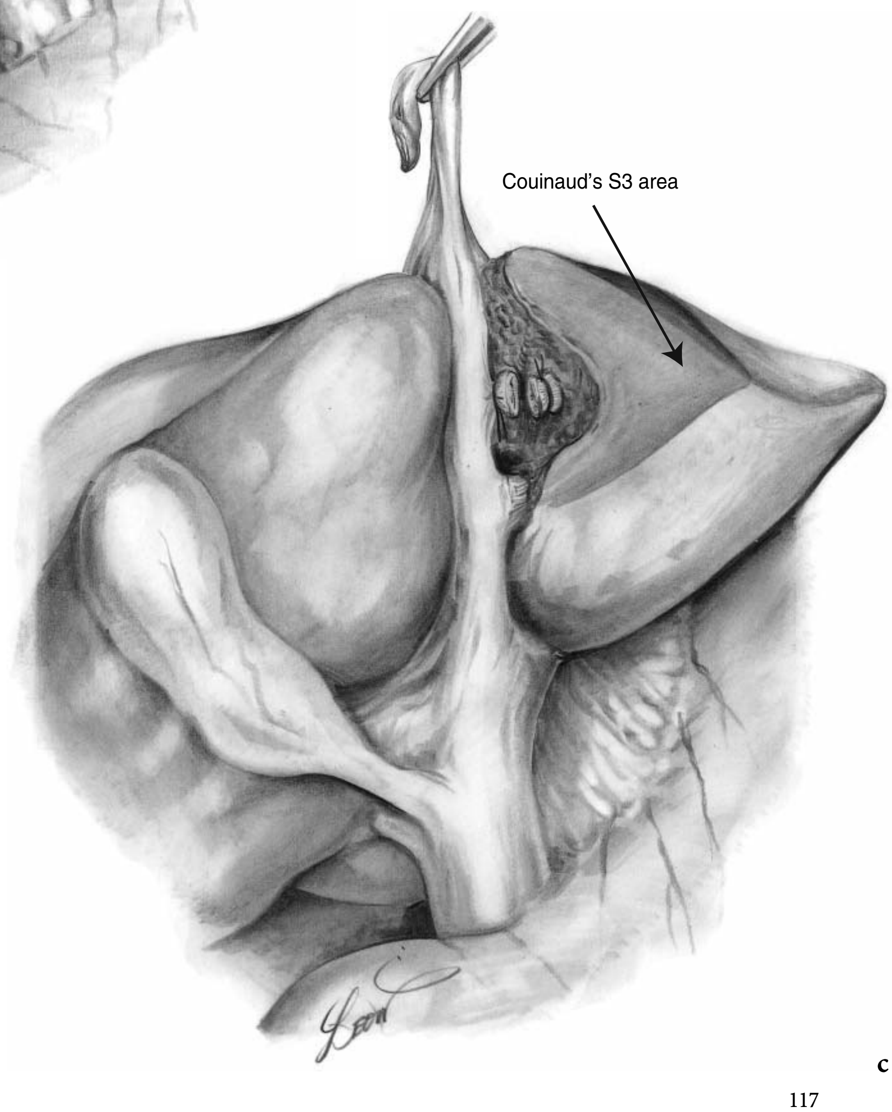
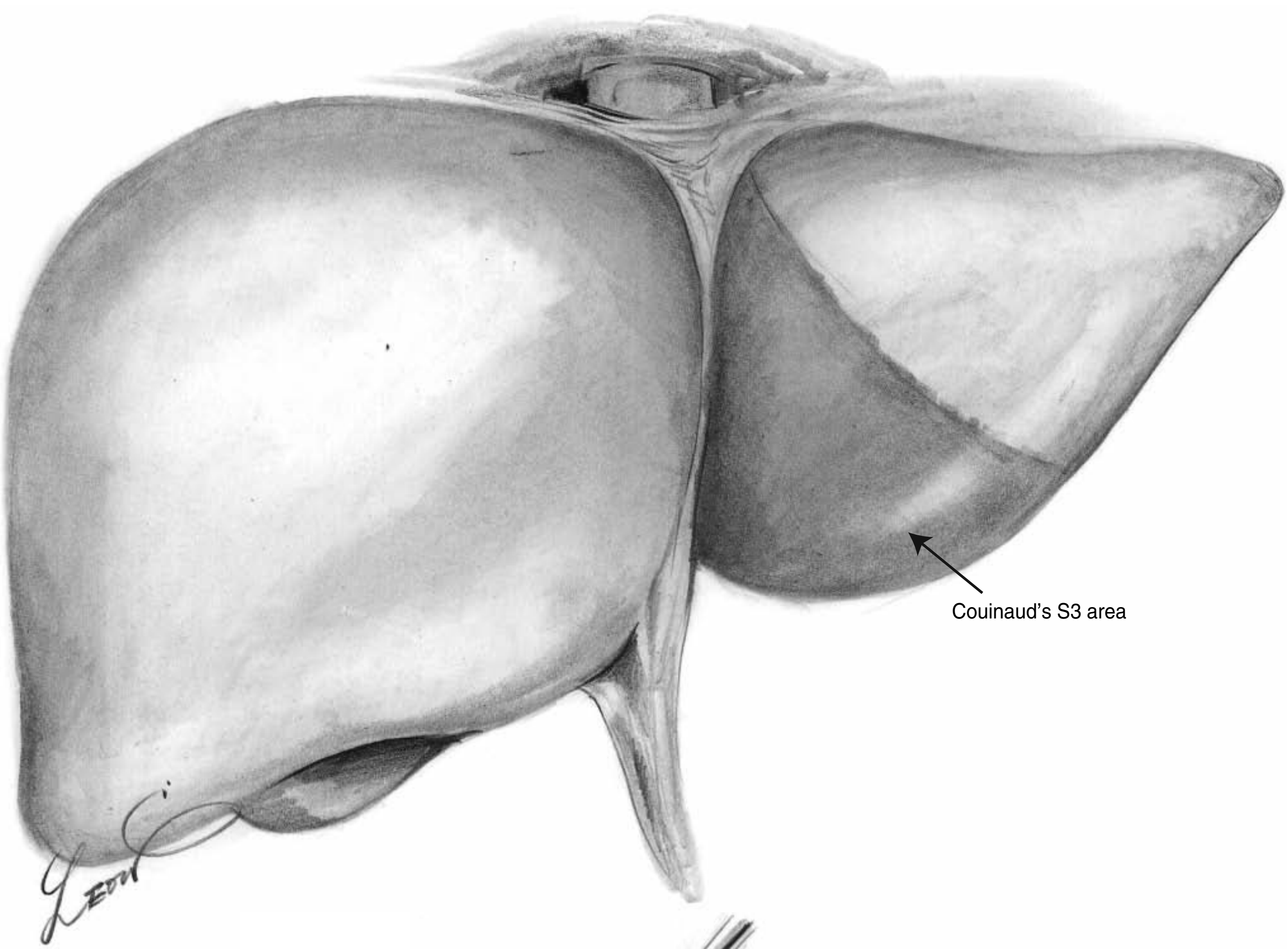
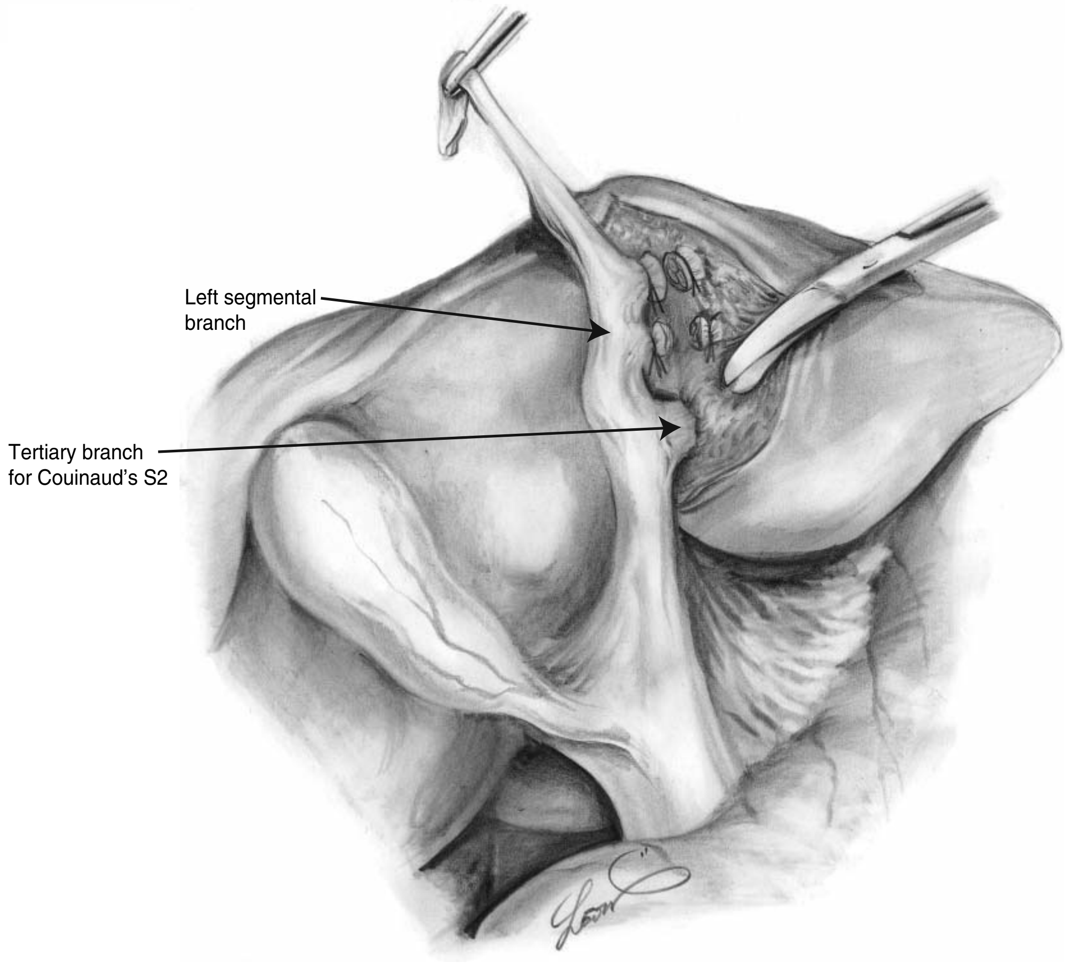


Fig. 7.24c,d. S3 area is demarcated

c

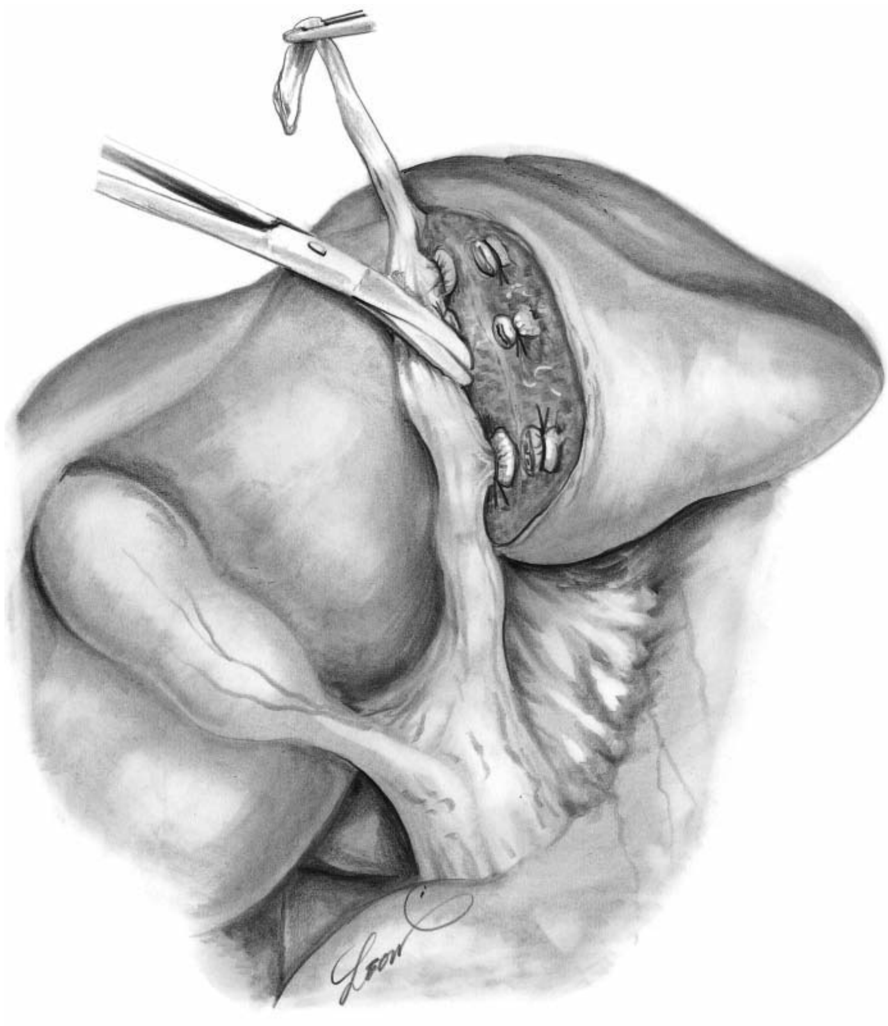


d



e

Fig. 7.24e. Strip the liver parenchyma along the main trunk of the left segmental branch toward the hepatic hilum. The tertiary branch for Couinaud's S2 comes into view

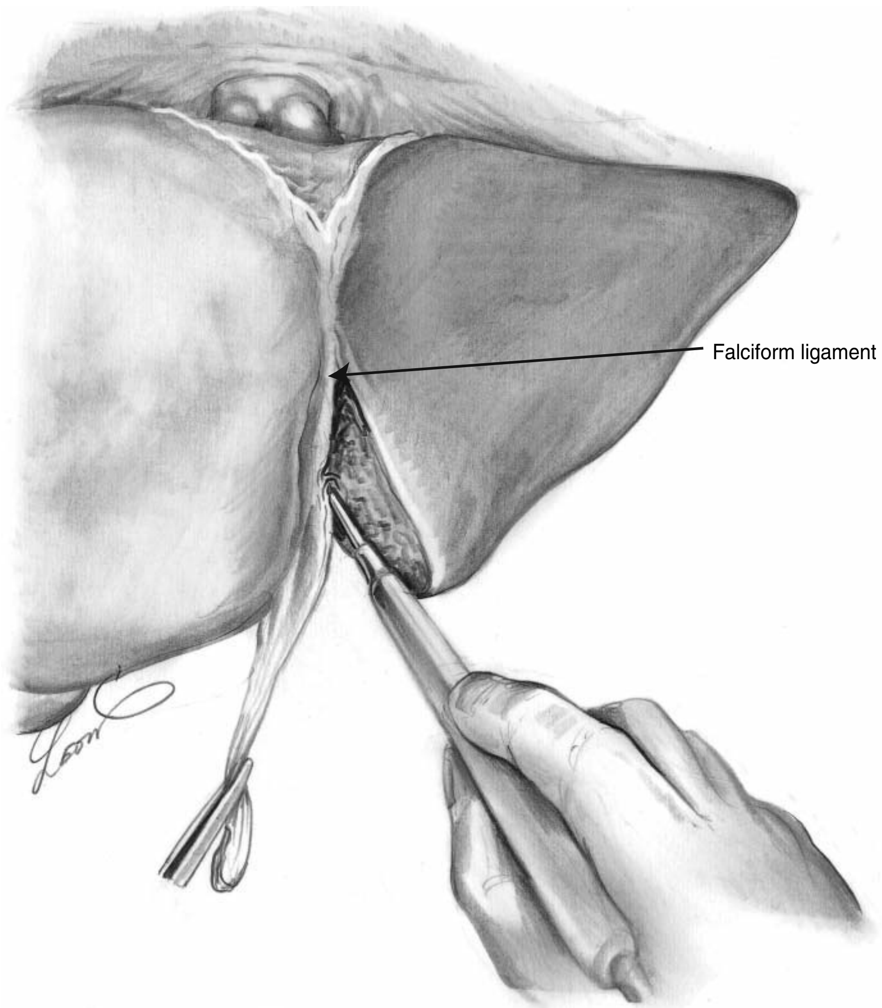


f

Fig. 7.24f. Transection of tertiary branches to the left lateral area is completed

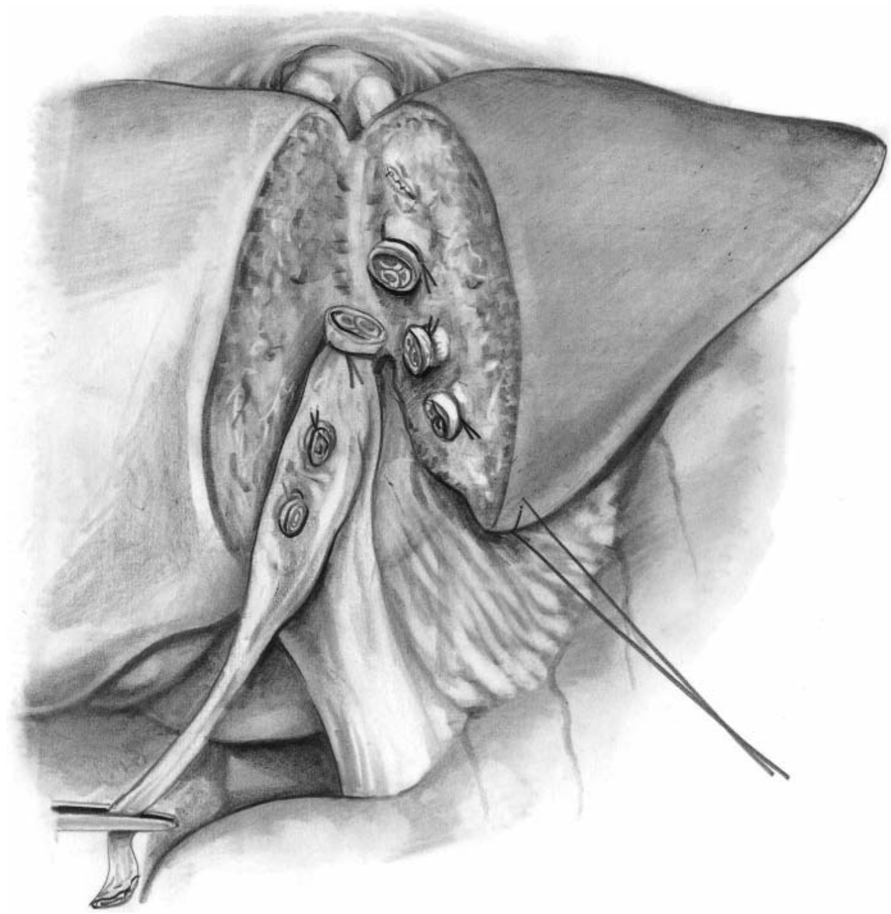
Transection of the Liver Parenchyma (Fig. 7.25a,b)

This is done on the line along the left side of the umbilical portion. The transection proceeds toward the duct of Arantius, which lies on the line of attachment of the hepatogastric ligament to the liver. The duct of Arantius must be preserved.



a

Fig. 7.25a. Transection of liver parenchyma



b

Fig. 7.25b. Parenchymal dissection is done

Transection of the Left Hepatic Vein (Fig. 7.26)

Careful attention must be paid to how the left hepatic vein merges with the IVC. This occurs in two ways. In one, the left hepatic vein enters the IVC directly. In the other, the left hepatic vein merges with the middle hepatic vein, which flows into the IVC. In the former case, the left hepatic vein is cut at the point of entrance into the IVC, and this is rather easy. In the latter case, however, careful attention must be paid not to cut the left hepatic vein at the entrance of the common vessels, but to cut it exactly at the merging point, so as not to allow narrowing.

Figure 7.26 shows the completed left lateral area resection. There are some cut stumps of tertiary branches at the umbilical portion of the left segmental branch. The small omentum remains intact.

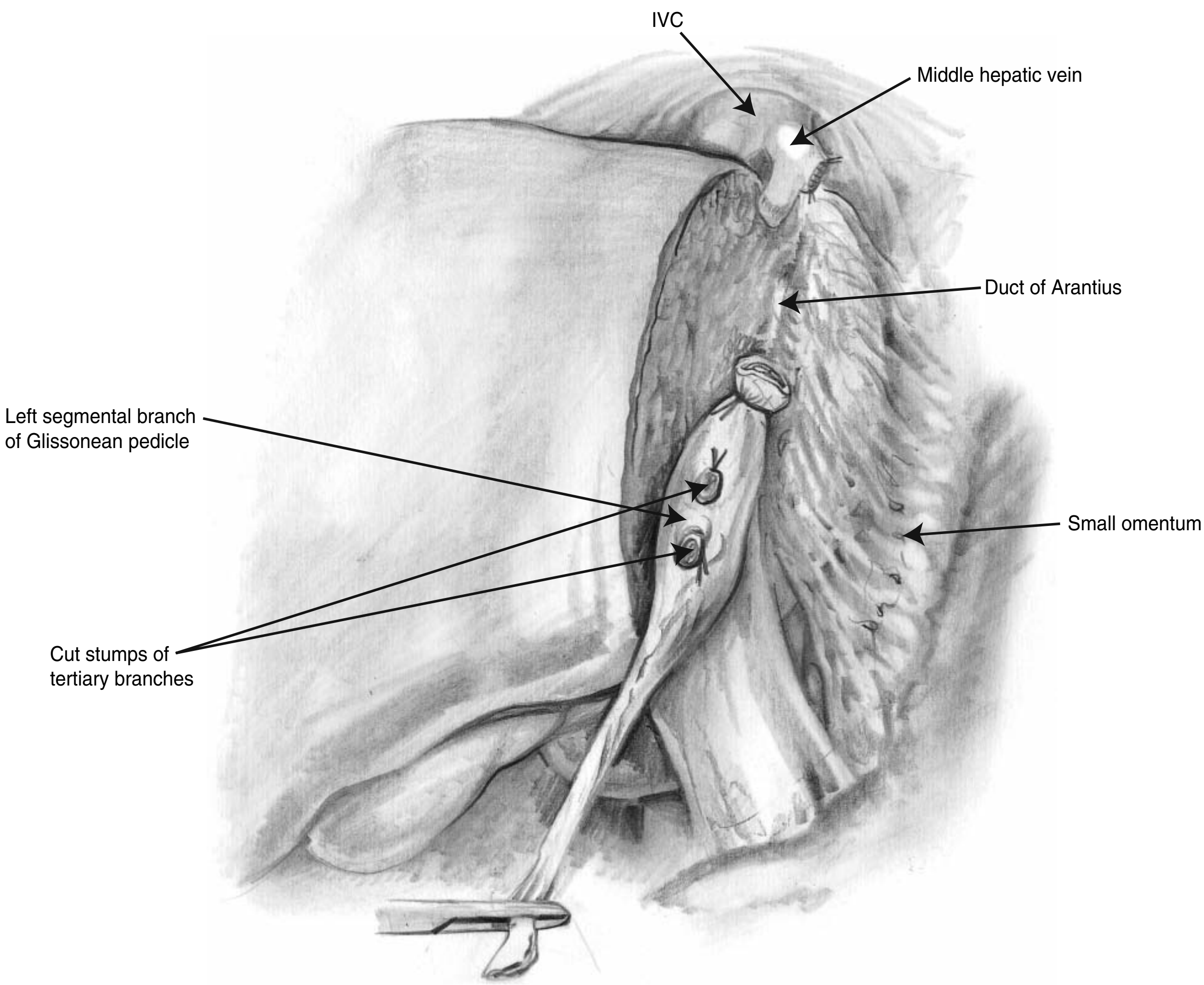


Fig. 7.26. Resection is completed

Resection of the Right Inferior Part (Couinaud's S6 Resection)

Tertiary branch(es), single or multiple, close to the hepatic hilum arising from the right segmental branch should be resected (Fig. 7.27). In order to see the intersegmental plane between the right and middle segments, clamp the already taped right segmental branch (Fig. 7.28). Several centimeters of liver parenchyma should be dissected on the hilum along the intersegmental plane. The liver parenchyma that is supplied by several tertiary branches which control the S6 area should be dissected.

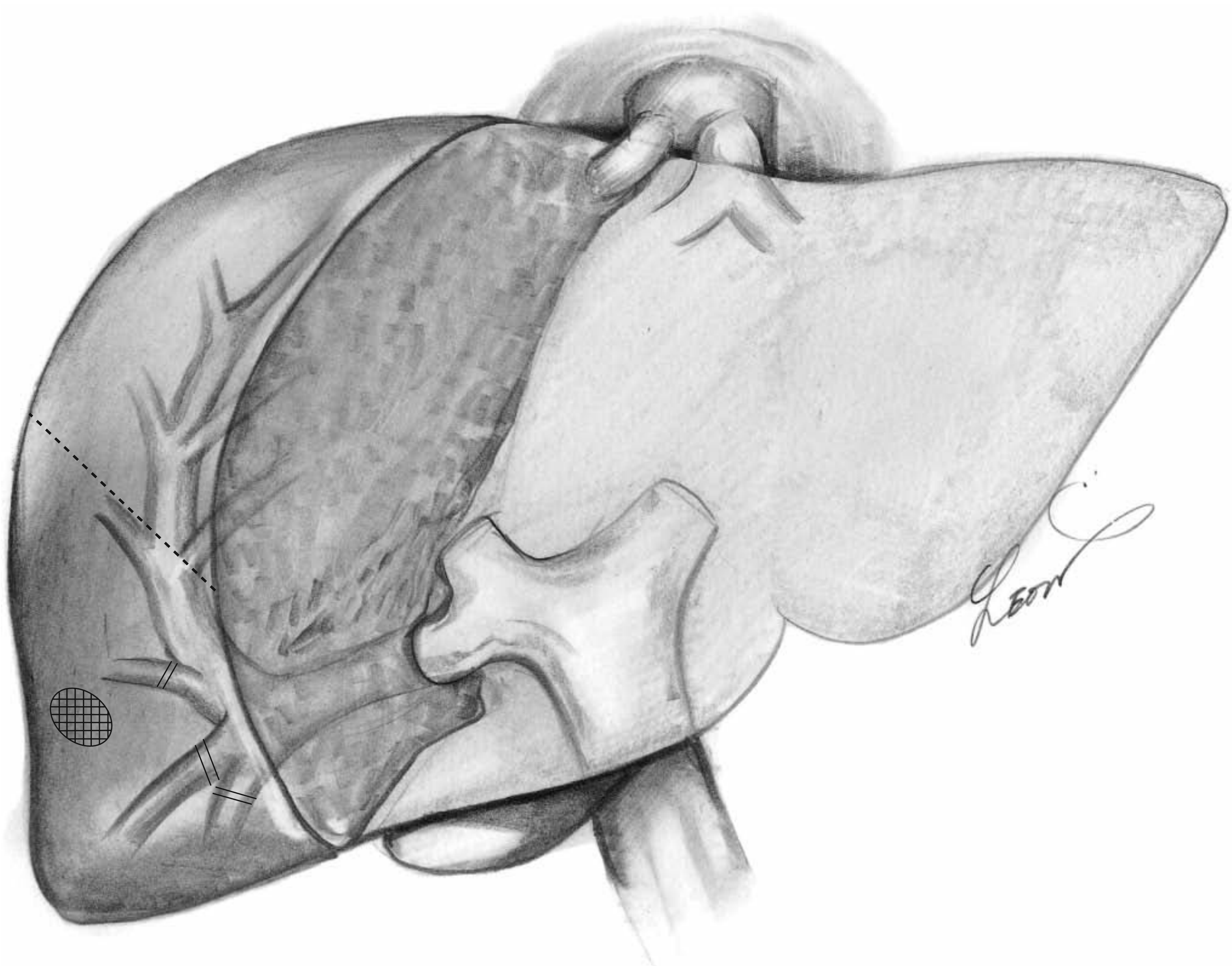


Fig. 7.27. Tertiary branches that ramify from the right segmental pedicle near the hepatic hilus are the branches of S6

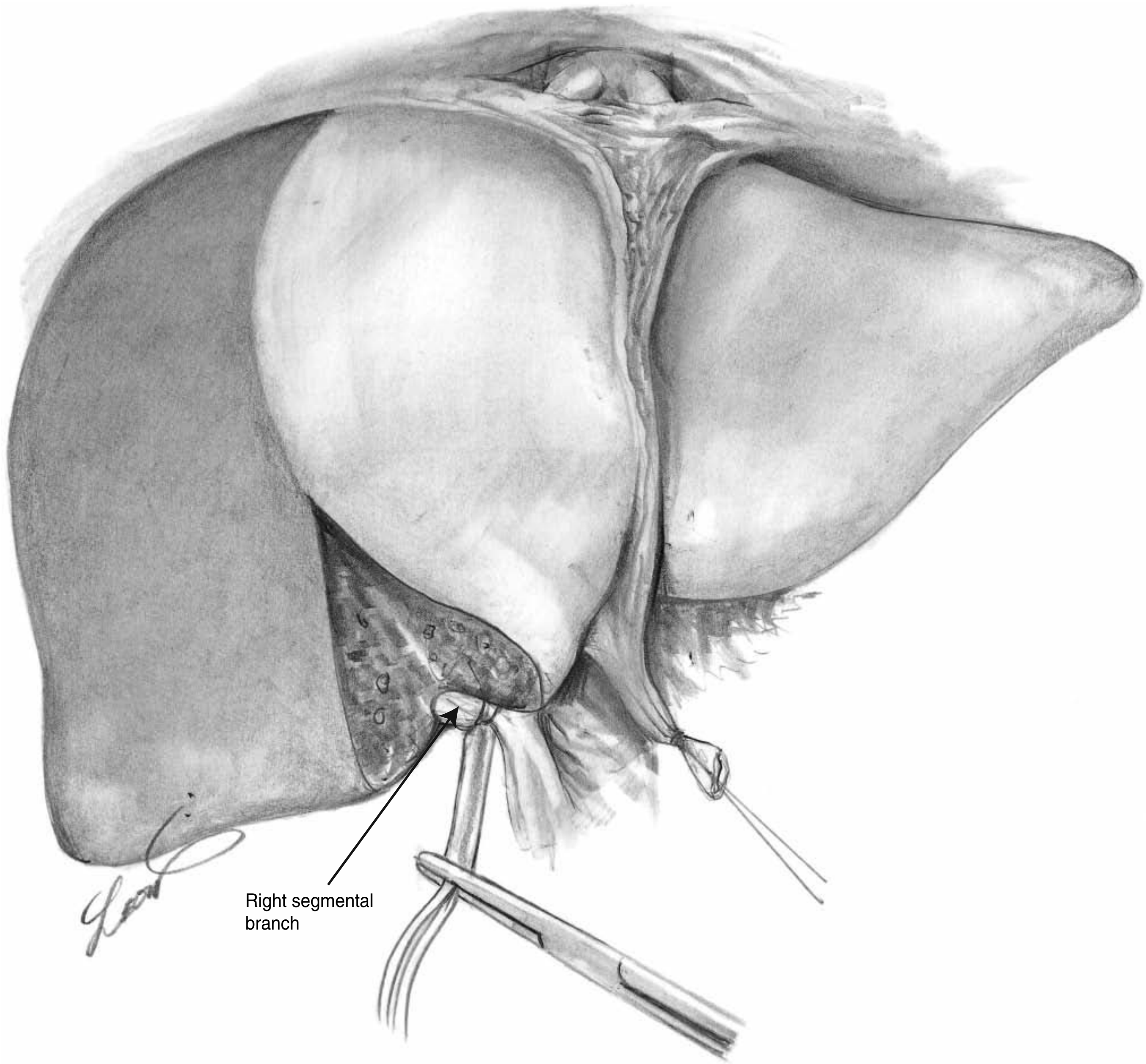


Fig. 7.28. Intersegmental plane between the right and middle segments is clearly shown by clamping of right segmental branch

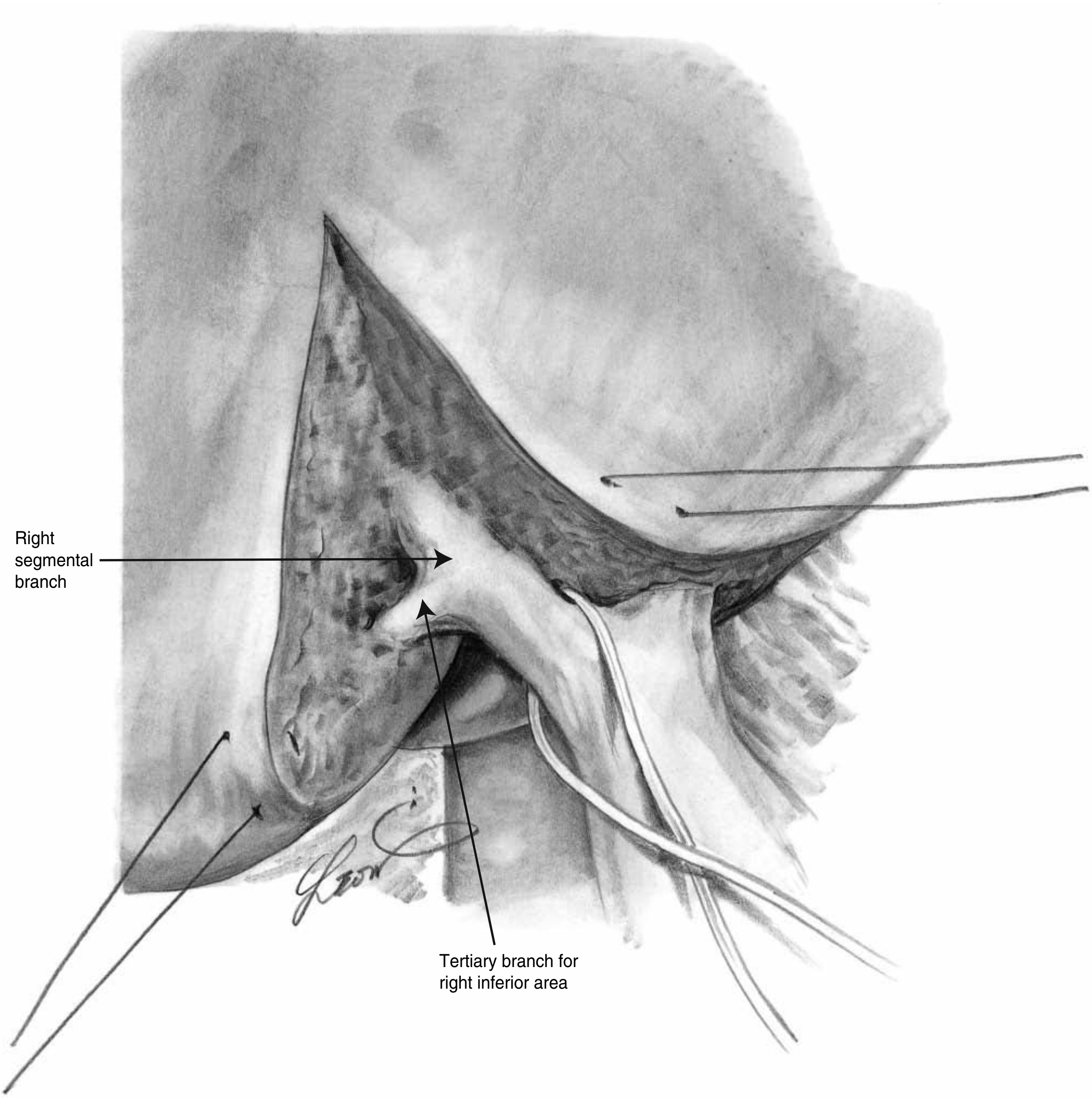


Fig. 7.29. After dissection of liver parenchyma, the right segmental branch and some tertiary branches which ramified from this branch come into view

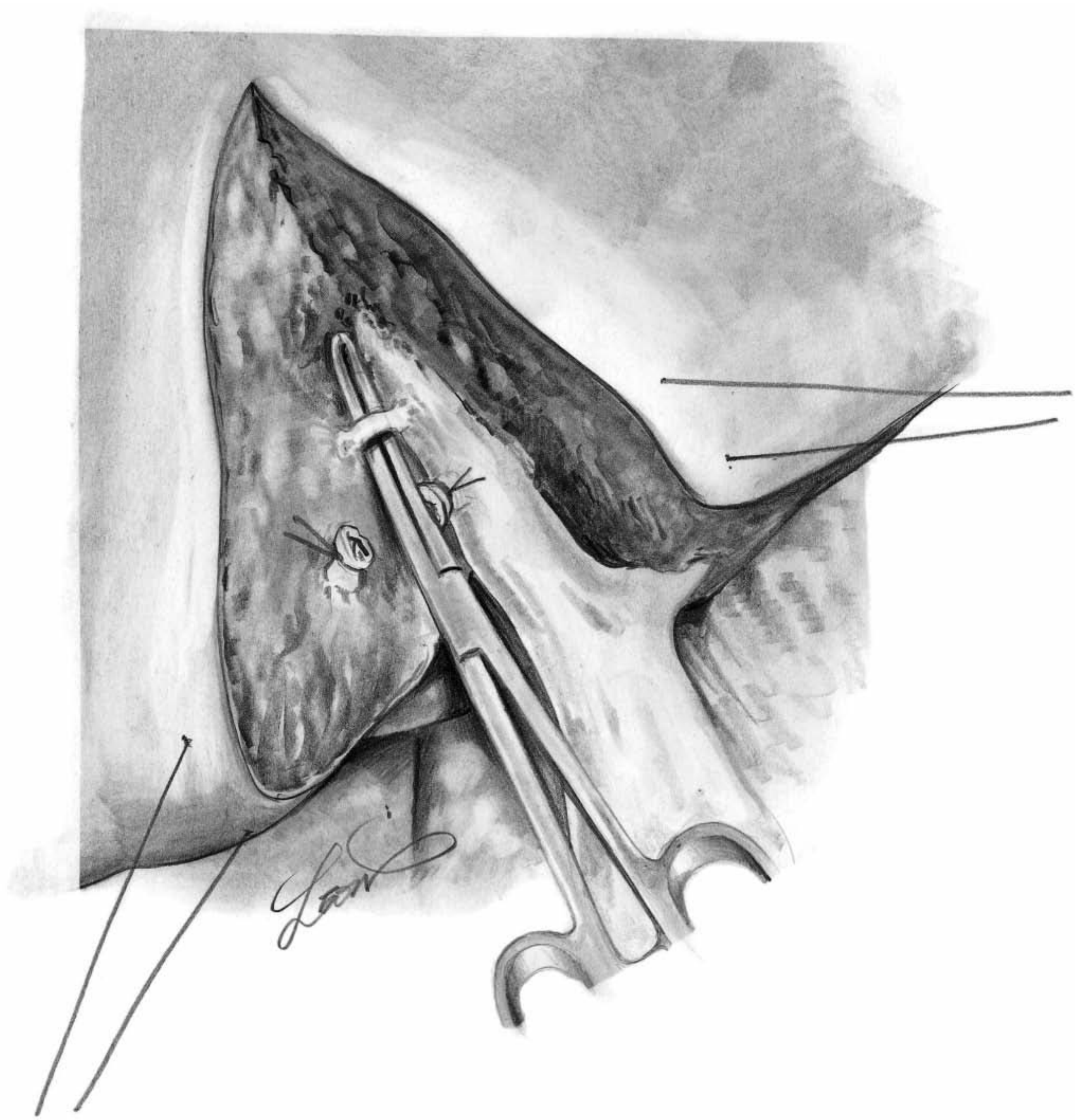


Fig. 7.30. Some tertiary branches must be cut under the control of the area which must be resected according to color change of the applicable area of the liver parenchyma

The number of cone units which must be dissected is controlled by change of color of liver surface after clamping the applicable tertiary branches. If the demarcated area is too small for radical resection of the tumor, another tertiary branch should be clamped. Further incision of the hepatic parenchyma to open the hepatic hilum is required if the tertiary branch(es) to be ligated is (are) too deep to manipulate. Then the tertiary branch(es) is (are) ligated and cut.

Transection is done on the demarcated line on the liver surface. The resection incision should be directed from the liver surface to the cut end of the tertiary branch(es) deep in the liver.

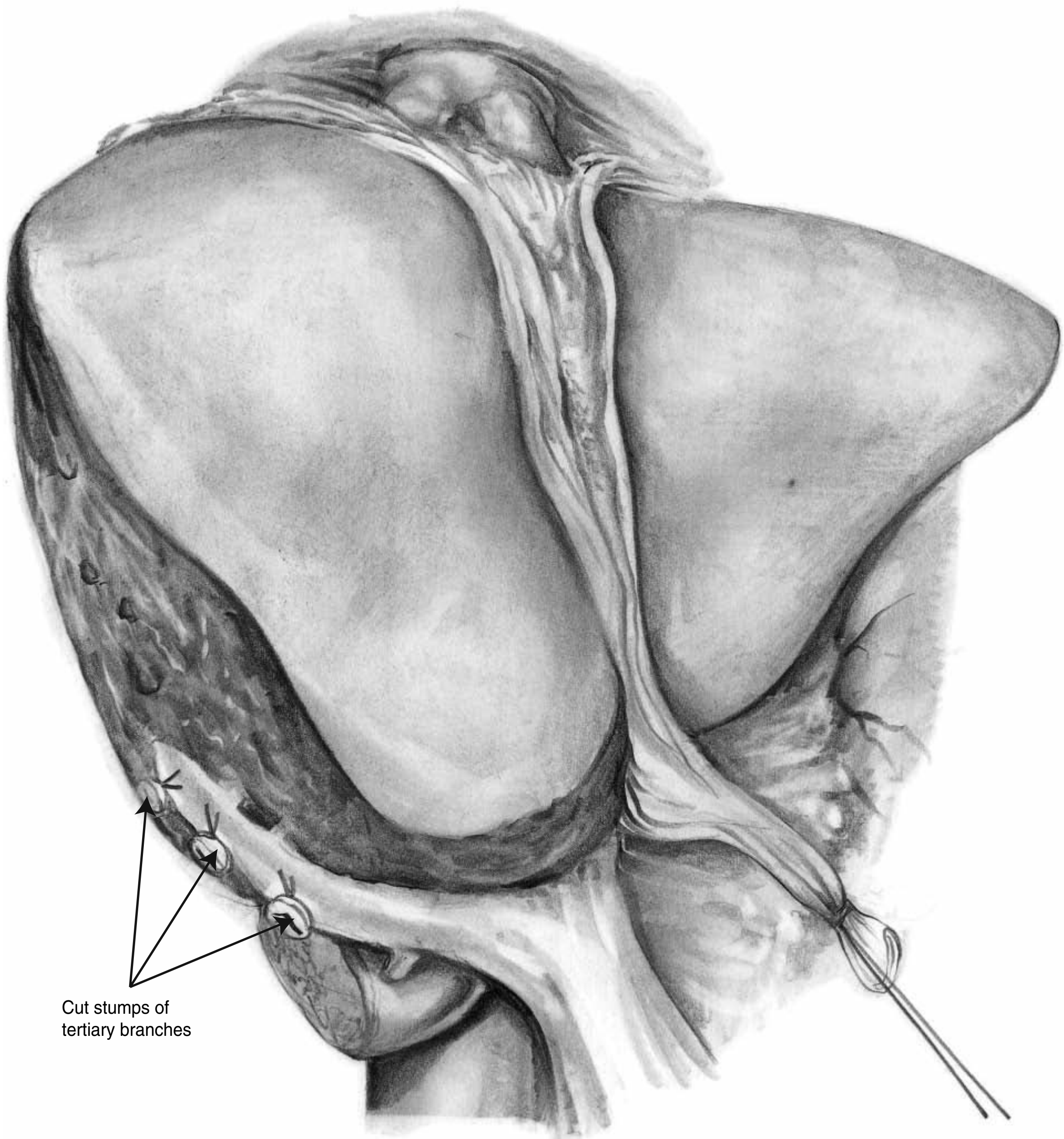


Fig. 7.31. Lower part of right segment resection is completed

Resection of the Middle Inferior Area (Couinaud's S5)

The feeders of this area are a few tertiary branches ramified from the middle segmental branch near the hepatic hilum (Fig. 7.32). The procedure for this resection is essentially the same as that for an S6 resection. First, the border between the left and the middle segment is identified by the clamping of the middle segmental branch. Then, the liver parenchyma is dissected along this plane to a depth of about 5 to 6 cm caudally, reaching the trunk of the middle segmental branch (Fig. 7.33a). Some tertiary branches ramifying from the middle segmental branch are ligated and cut, stepwise from the hilum to a point deep inside the liver, after having confirmed the area by clamping these tertiary branches. Liver dissection should be done on the demarcated line (Fig. 7.33b).

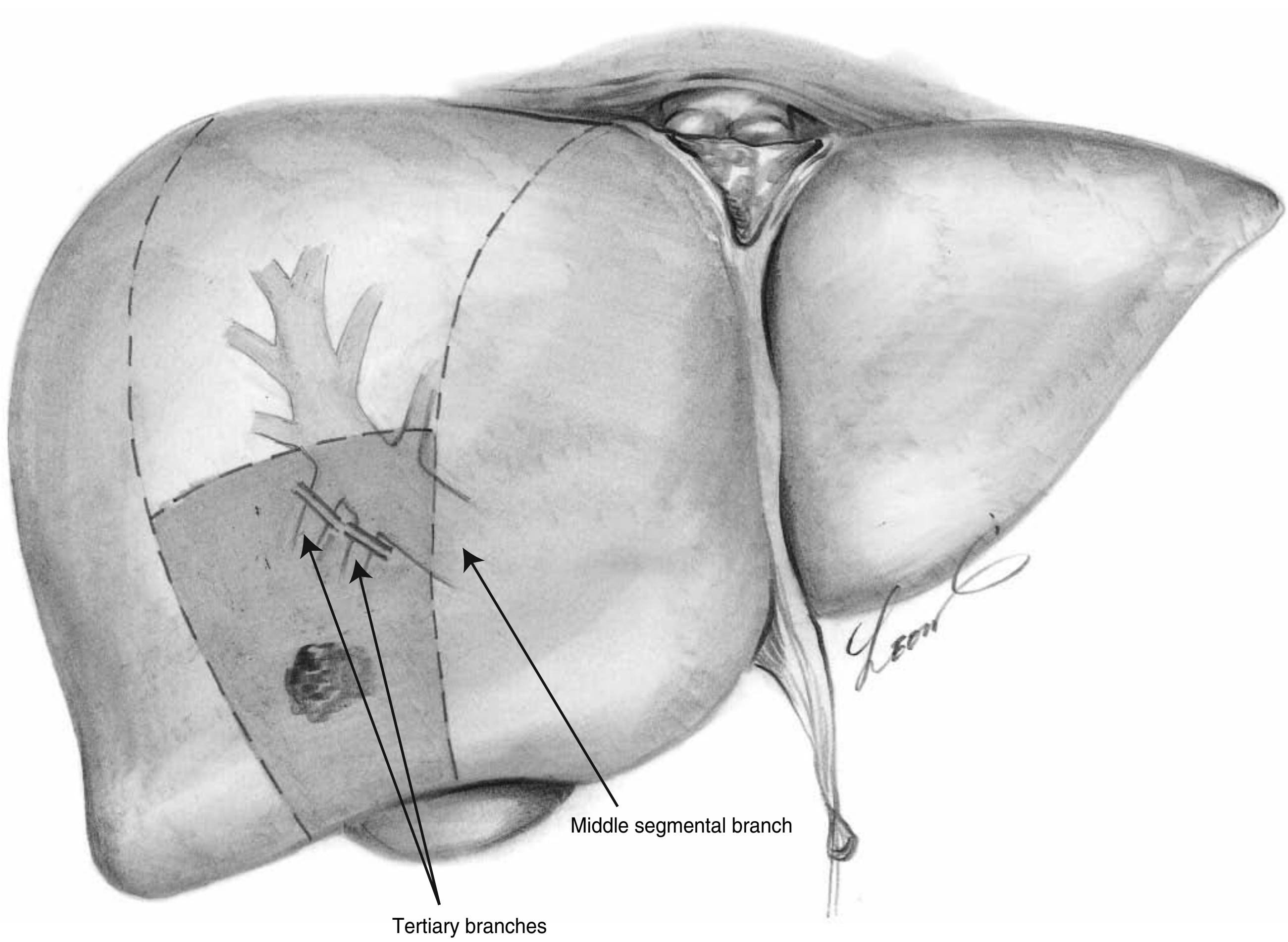


Fig. 7.32. The schema of Couinaud's S5 resection

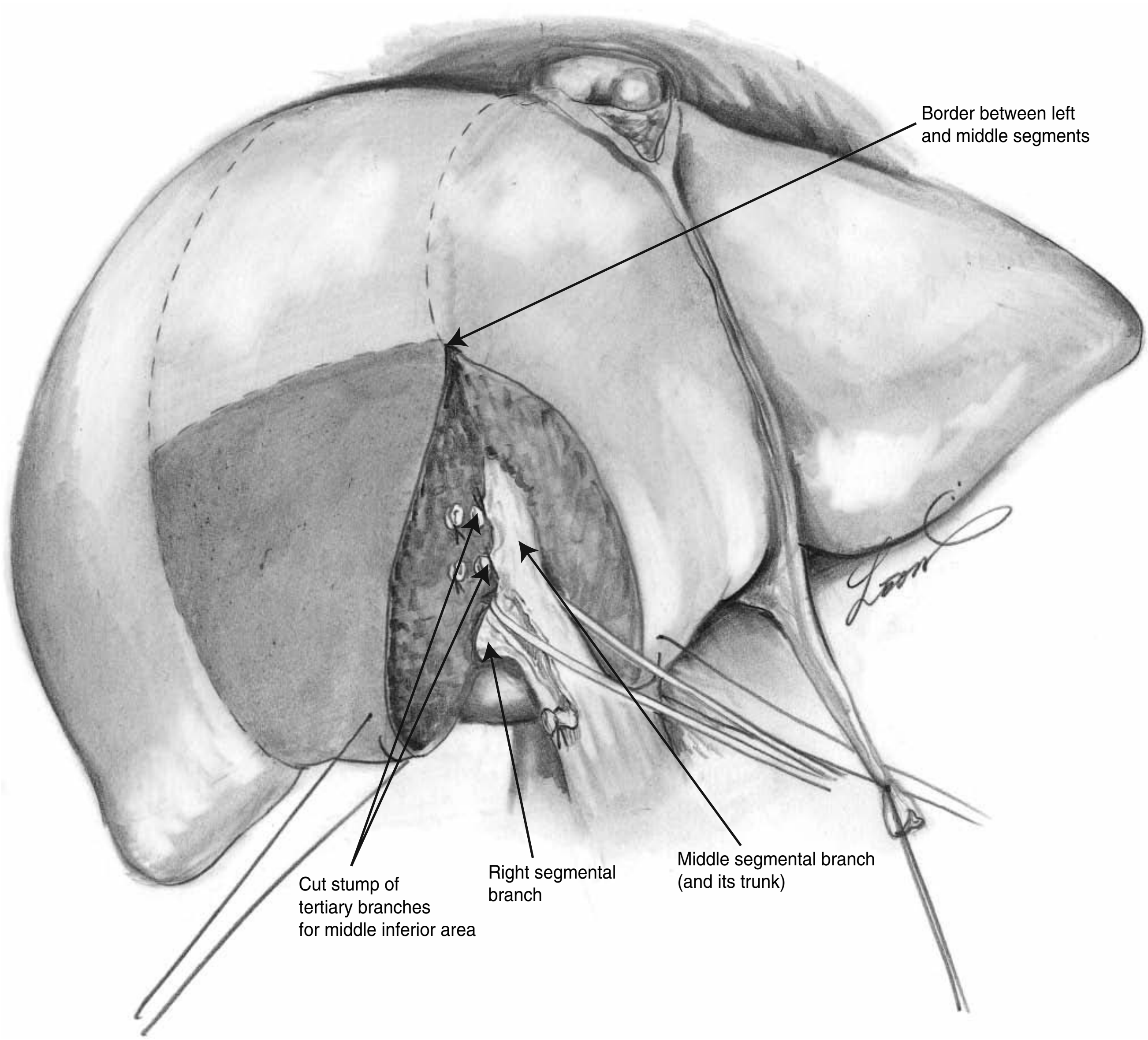
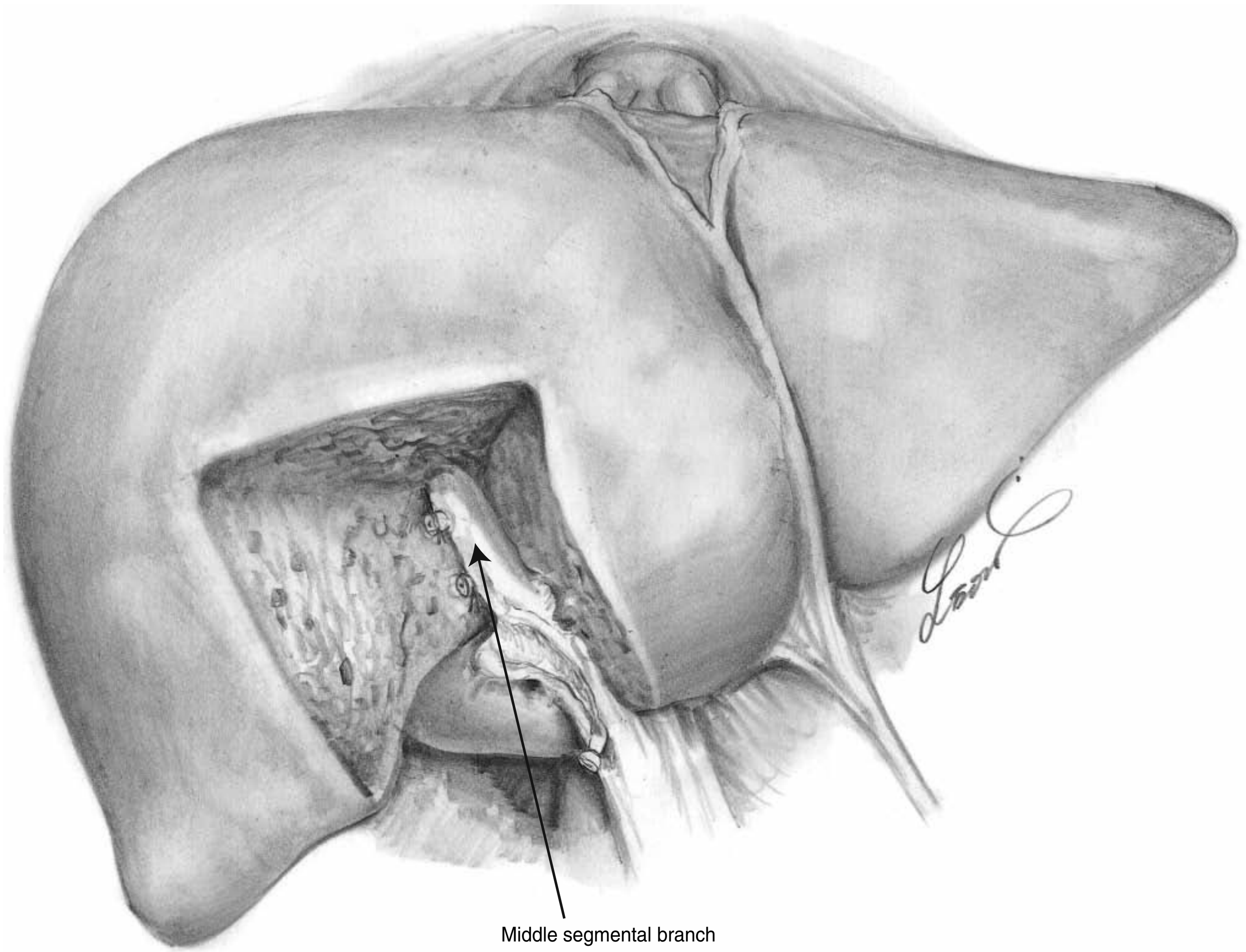


Fig. 7.33a. Procedure for S5 resection



b

Fig. 7.33b. Middle inferior area (Couinaud's S5) resection is completed

Resection of the Middle Superior Area (Couinaud's S8) (See DVD 2)

The tertiary branches of the middle segmental branch distant from the hepatic hilum nourish the middle superior area. Transection takes place at the mid-portion of the middle branch of the Glissonean pedicle (Fig. 7.34). The tertiary branches supplying this area ramify from the main trunk of the middle segmental branch deep inside the liver; therefore, the parenchymal approach is introduced.

A temporary clamp is applied to the middle segmental branch (Fig. 7.35a). The borderline of the left segment should be confirmed by the demarcation line. Dissection proceeds along this demarcated line in a direction toward the hepatic hilum; then the middle hepatic vein is seen along the incision. This middle hepatic vein is to remain intact and is to be placed along the remaining side of the cut surface. Dissection continues up to the middle segmental branch (Fig. 7.35b). The peripheral part of the middle segmental

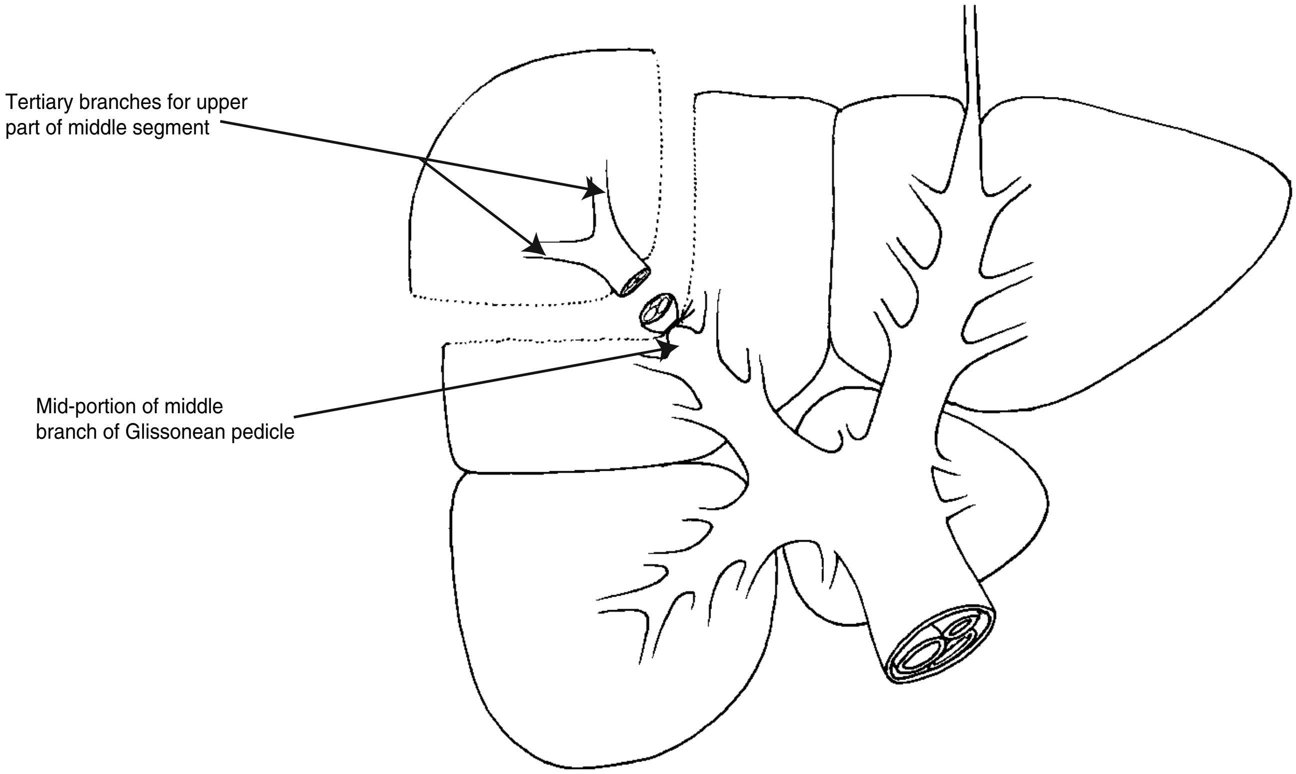
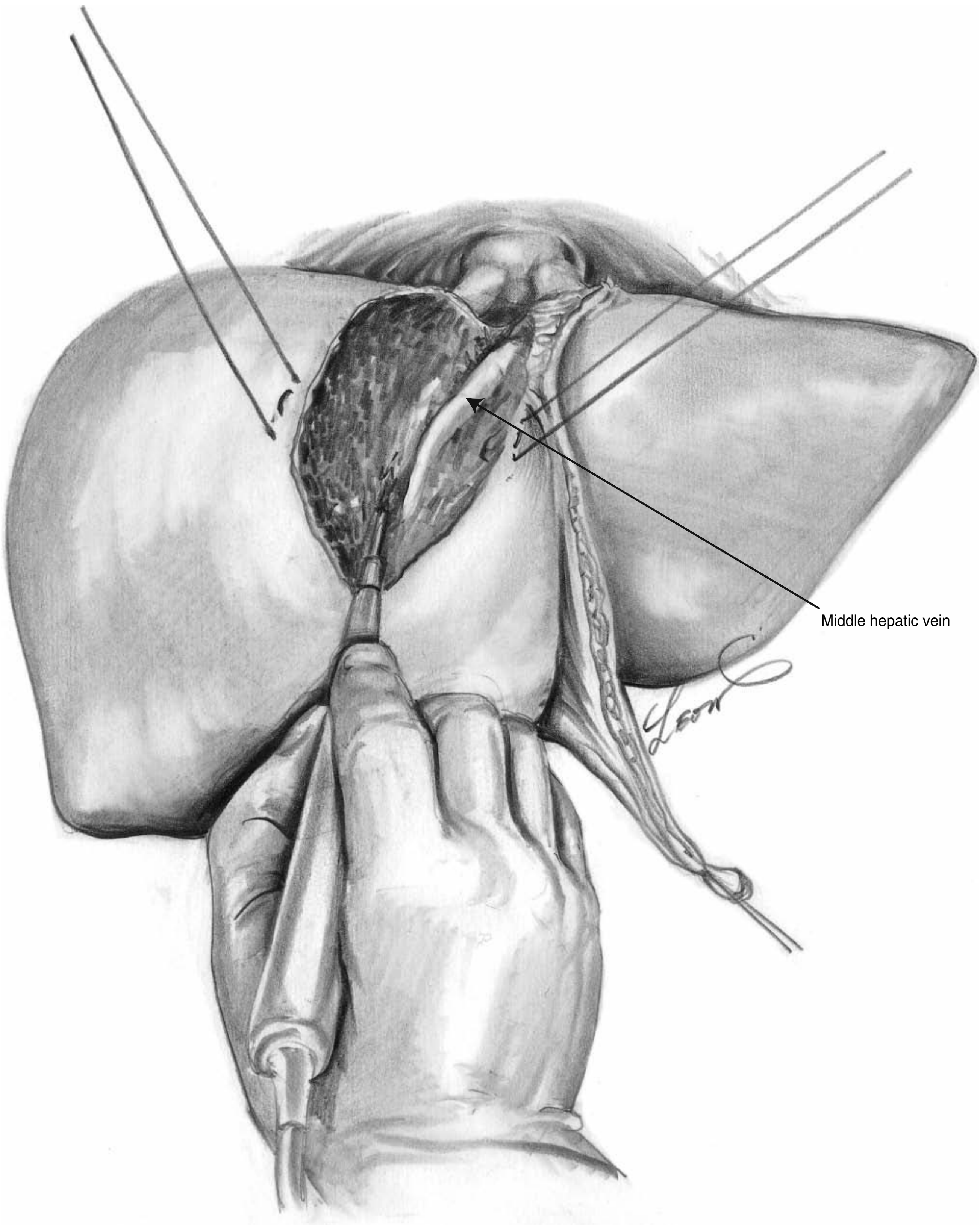


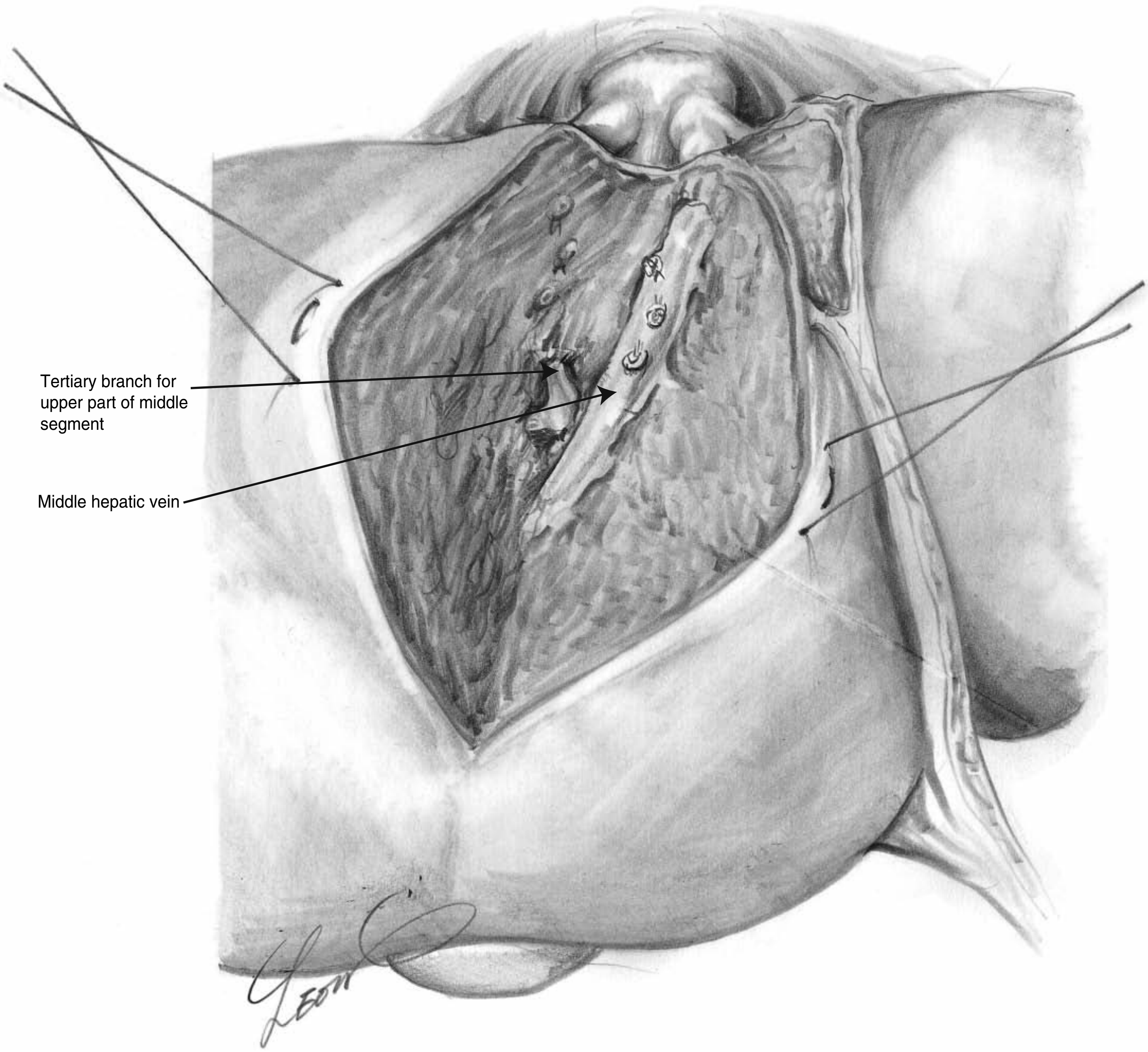
Fig. 7.34. Schema of resection of Couinaud's S8

branch can be cut (Fig. 7.35c). Liver dissection may be done on the demarcated line. The direction of dissection must be kept toward the cut stump of the segmental branch. After the resection of S8, there is a cone-shaped hole in the upper part of the liver. The cut stump of the segmental branch lies at the bottom of this hole and the cut stumps of the left hepatic vein and right hepatic vein lie on the cut surface of both sides of the liver parenchyma (Fig. 7.35d).



a

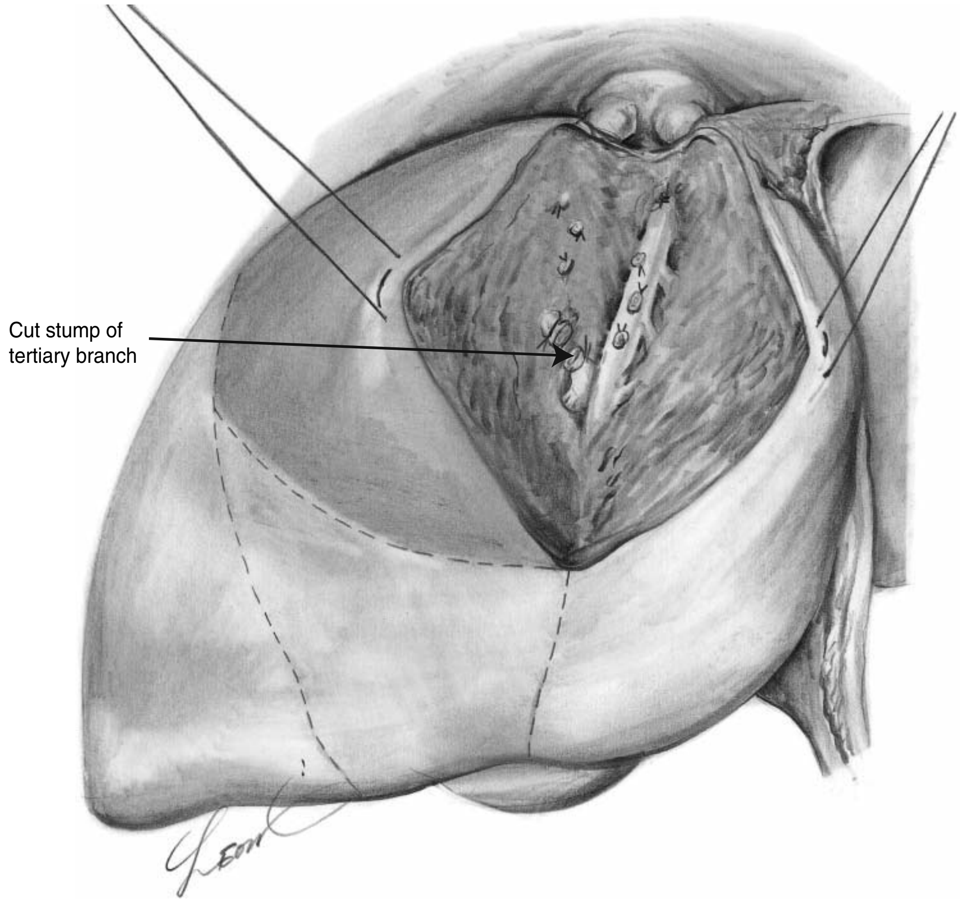
Fig. 7.35a. Procedure for resection of Couinaud's S8. First, middle segmental branch is clamped at the hepatic hilus. Liver parenchyma is dissected on the upper side of demarcated line



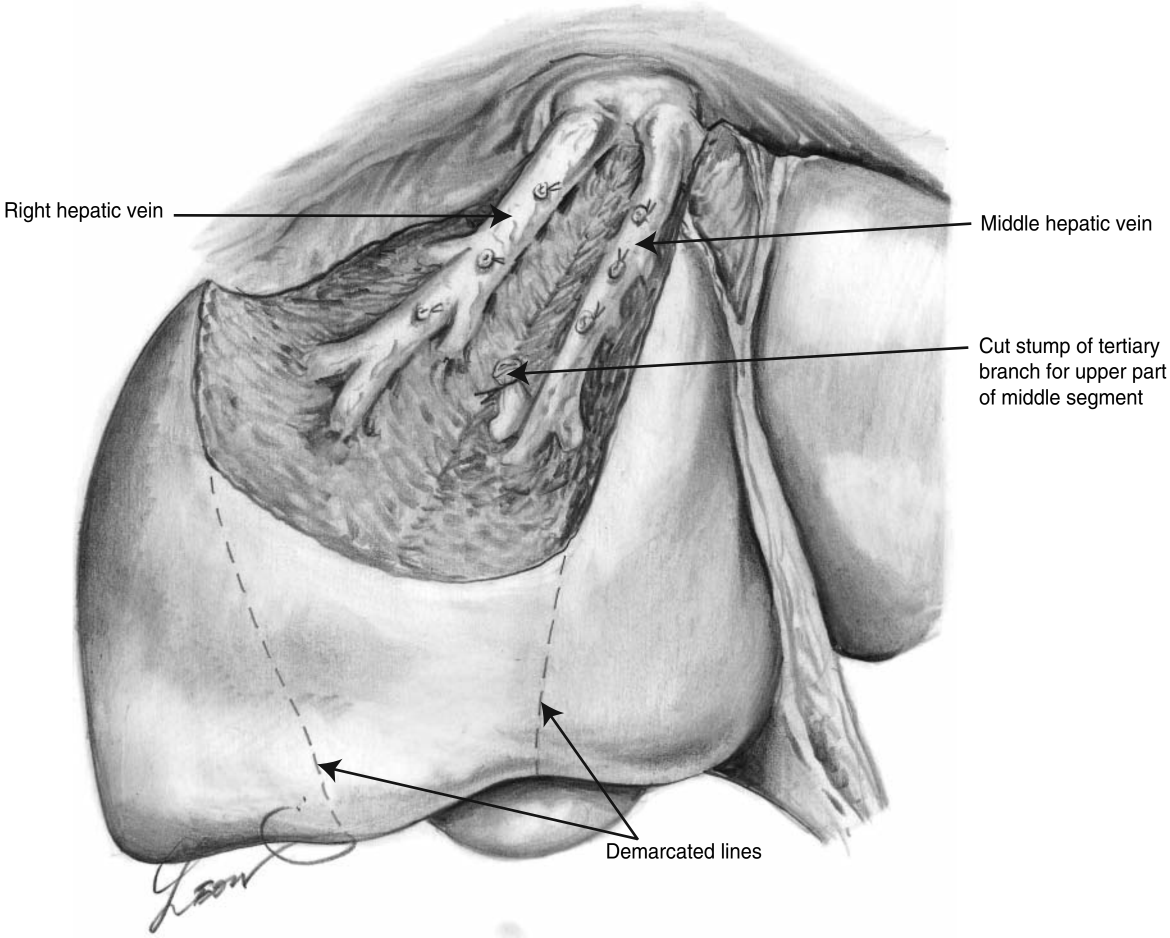
b

Fig. 7.35b. Dissection proceeds deeply into the liver. Tertiary branch for S8 area comes into existence on right side of the middle hepatic vein

Fig. 7.35c. After transecting the tertiary branch, an area fed by this branch is demarcated



c



d

Fig. 7.35d. At the cut surface of the liver are the lateral wall of the middle hepatic vein and the cut stump of the middle segmental Glissonean pedicle. Upper part of middle segment resection is completed

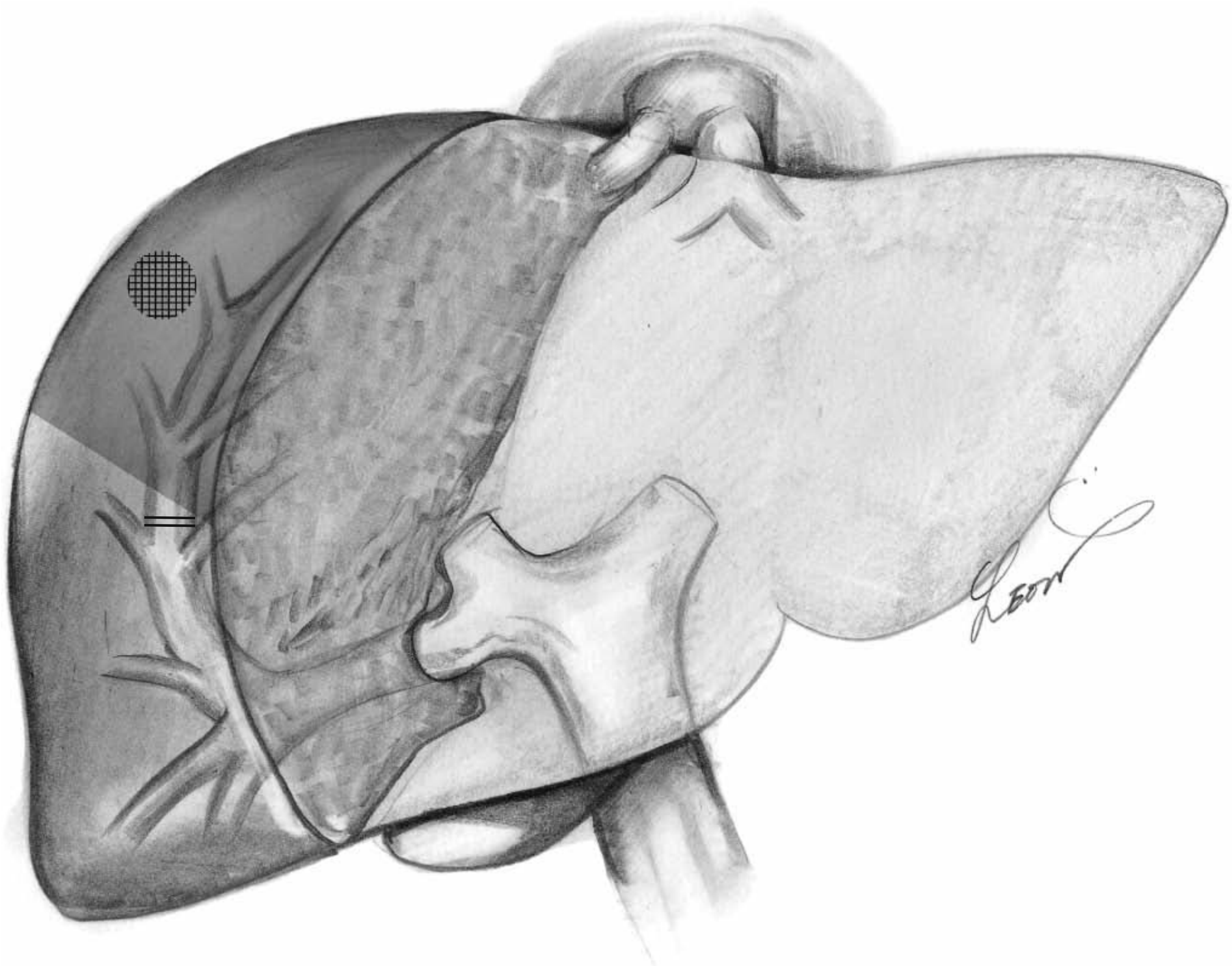


Fig. 7.36. This area is fed by the peripheral branch

Resection of the Right Superior Area (Couinaud's S7)

In this procedure, some tertiary branches which ramify from the right segmental branches are transected, and some cone units fed by these tertiary branches are resected (Fig. 7.36).

The tertiary branches of the upper part of right segment ramify from the right segmental branch distant from the hepatic hilum. Transection takes place at the mid-portion of the right segmental branch of the Glissonean pedicle.

The tertiary branches supplying this area branched out from the main trunk of the right segmental branch deep inside the liver; therefore, the parenchymal approach must be taken.

First, the right segmental branch is clamped temporary (Fig. 7.37). The borderline between the right segment and middle segment is confirmed by the demarcation line.

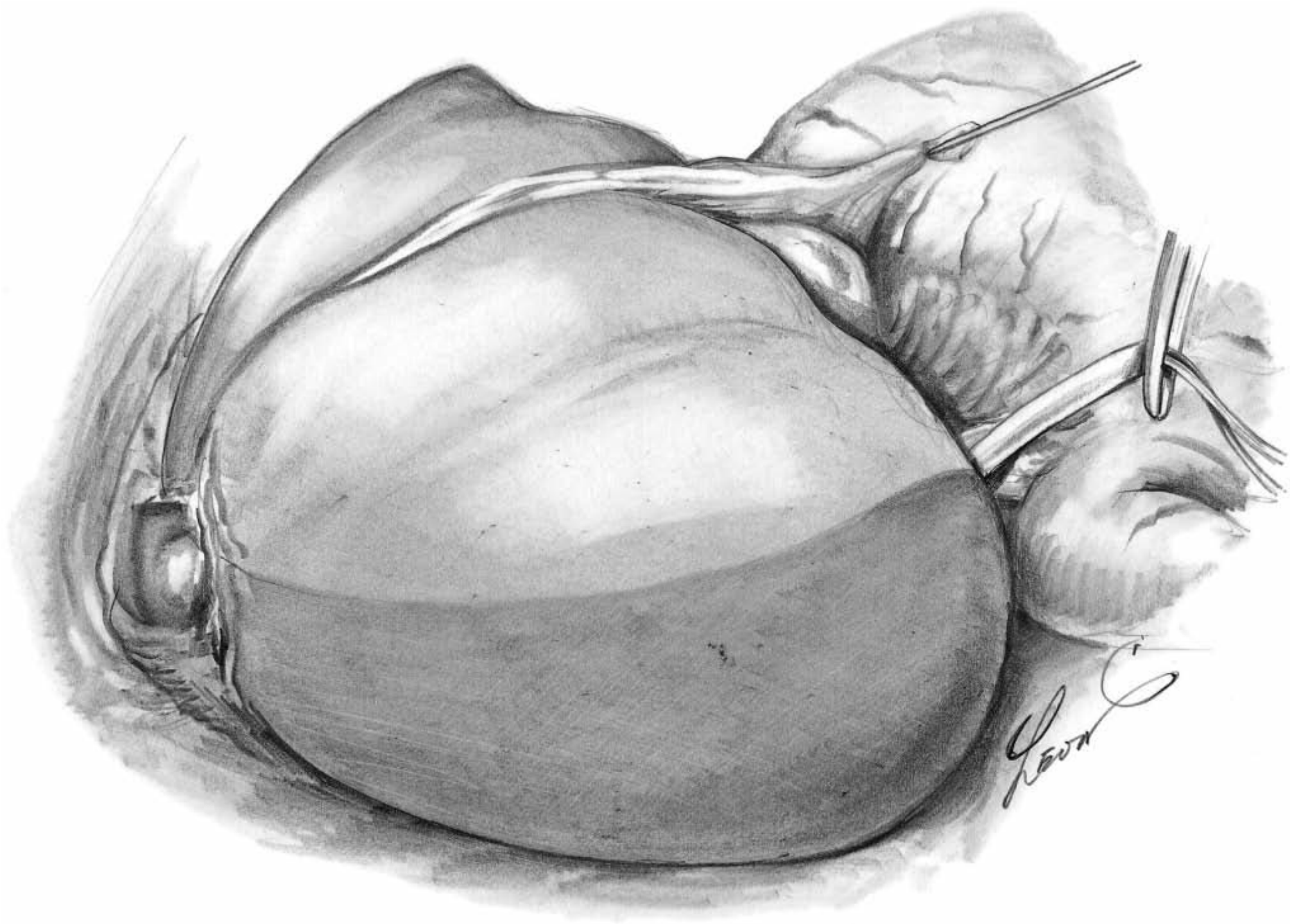


Fig. 7.37. Intersegmental plane between middle and right segments is recognized by change of color after clamping of right segmental branch

Dissection proceeds along this demarcated line; then the right hepatic vein is seen along the incision face. The right hepatic vein must remain intact (Fig. 7.38).

The peripheral part of the right segmental branch can be seen (Fig. 7.39). Transection of the peripherla part of the right segmental is done. Liver parenchymal dissection may be done on the demarcated line (Fig. 7.40).

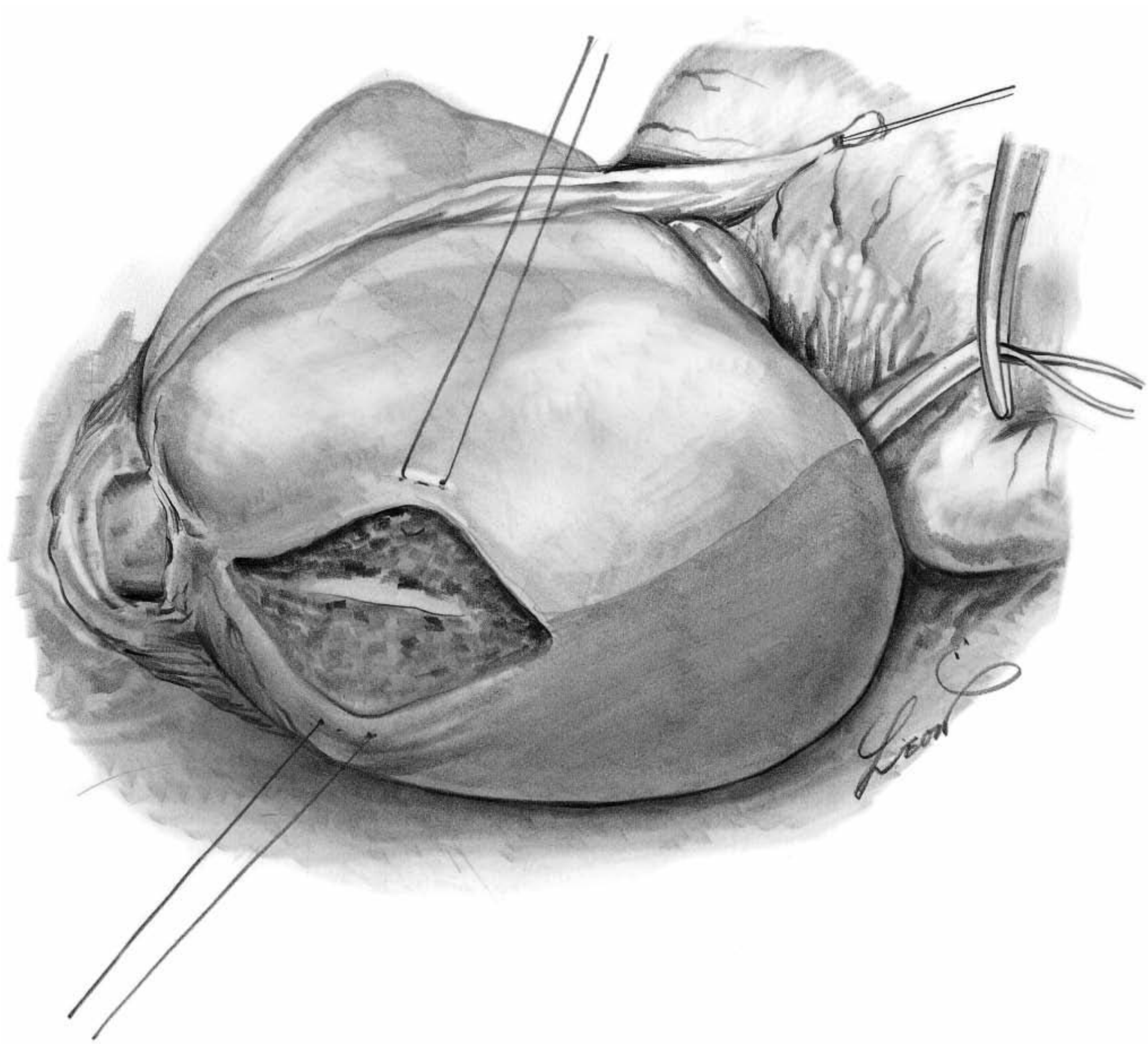


Fig. 7.38. Dissection of liver parenchyma is started on the upper part of demarcated line

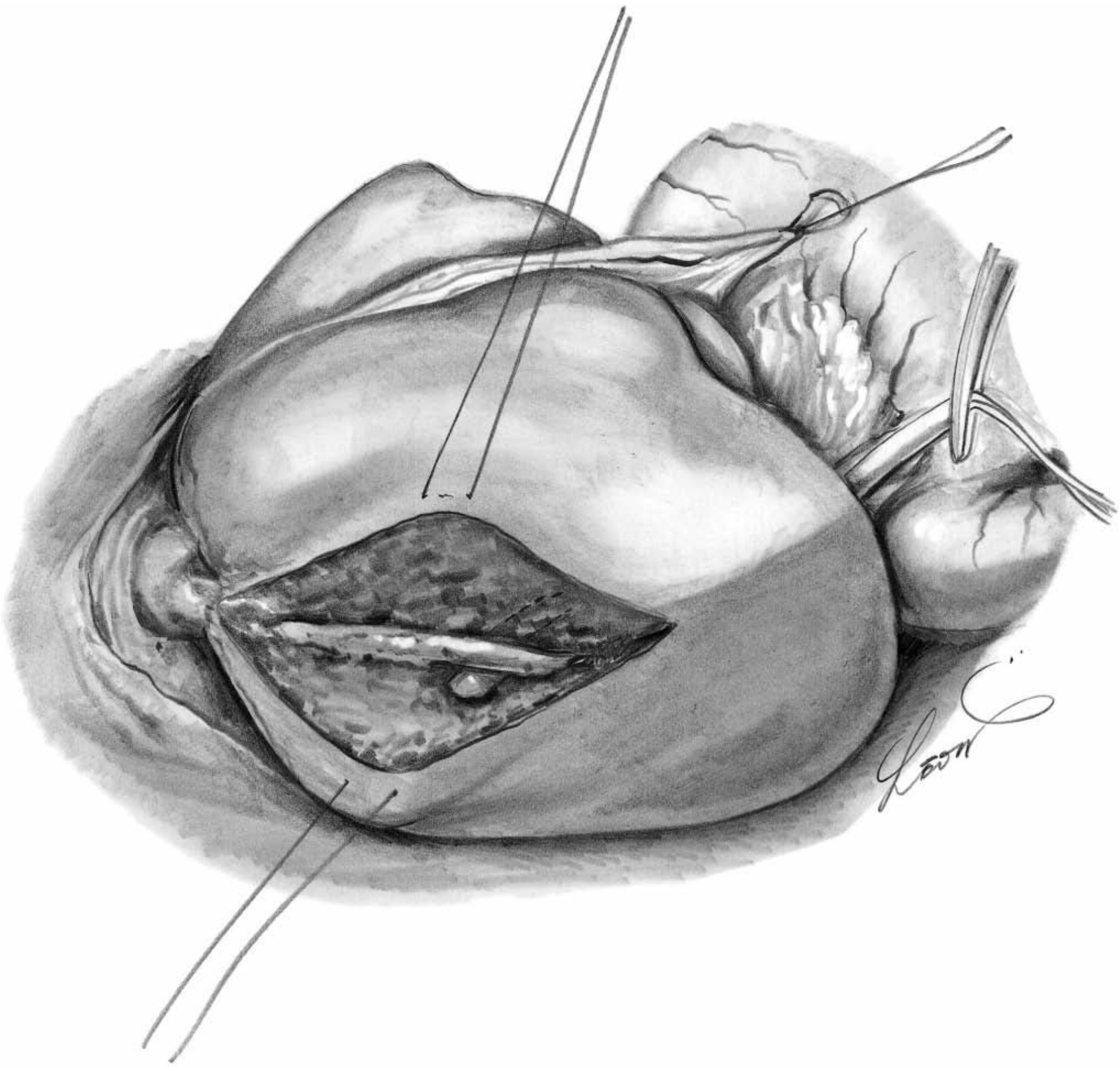


Fig. 7.39. Dissection proceeds deeply into the liver. The tertiary branch which distributes the upper part of the right segment comes into existence on dorsal side of right hepatic vein

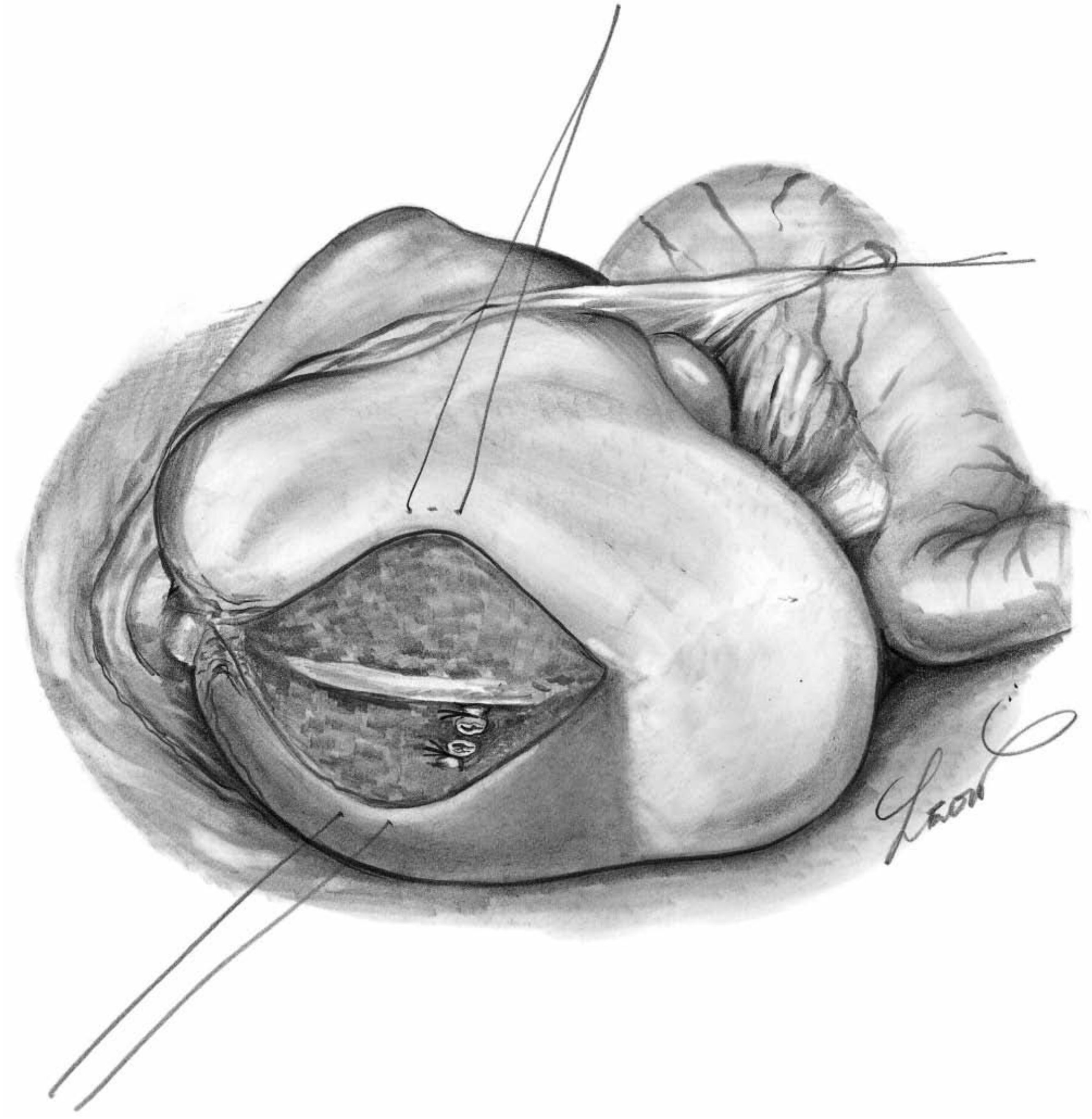


Fig. 7.40. Upper part of right segment is demarcated after transection of the tertiary branch

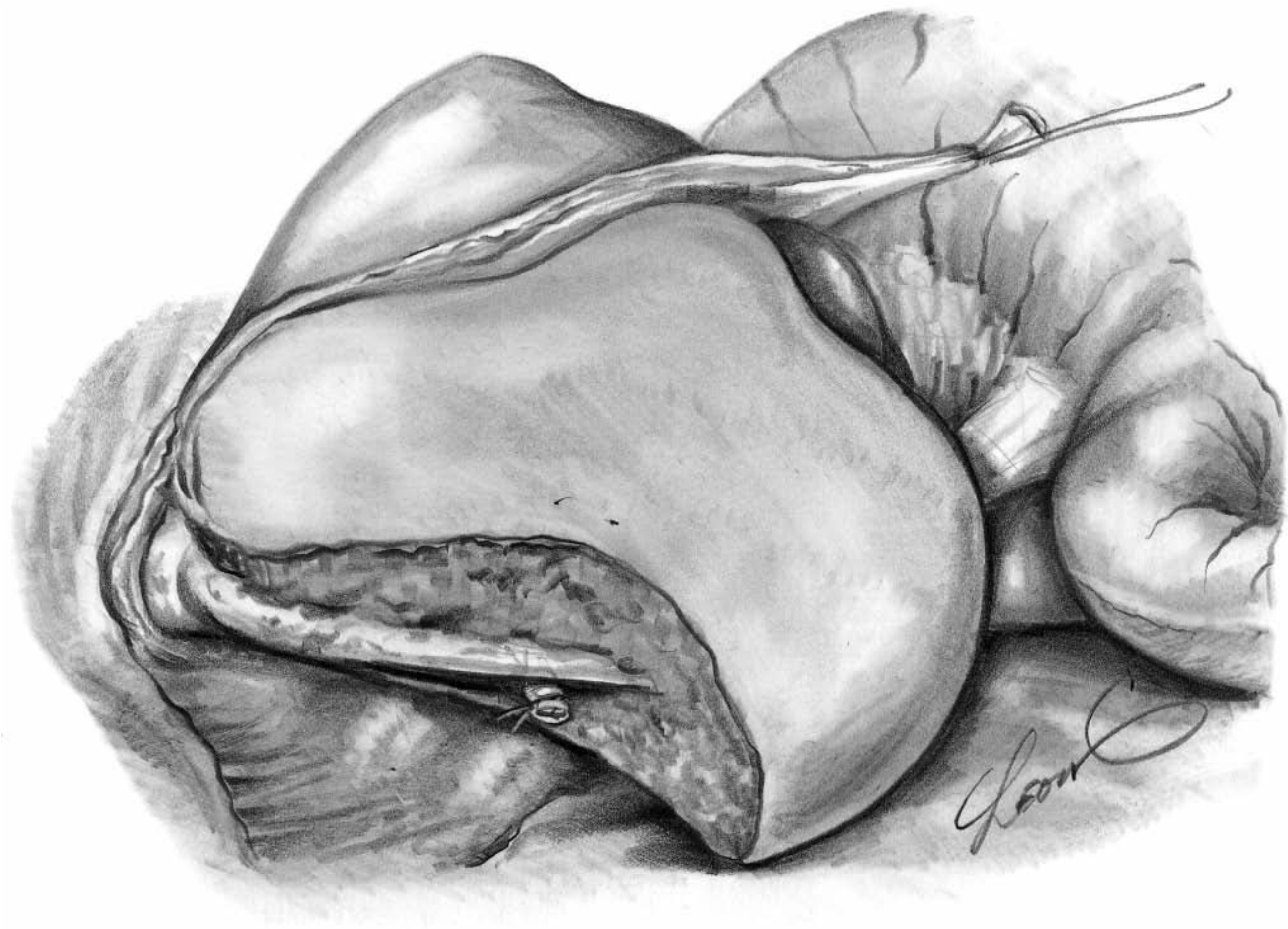


Fig. 7.41. Upper part of right segment resection is completed

The cut stump of the segmental branch lies at the bottom, and right hepatic vein lies on the cut surface of the liver parenchyma (Fig. 7.41).

Arbitrary Selective Cone Unit Resection

When a cancer nodule invades two neighboring segments, several cone units in both segments must be removed. Several tertiary branches must be selectively transected in both segments. The number of cone units to be resected is decided depending upon the size and location of the carcinoma.

Resection of the Inferior Part of the Right Lobe (Couinaud's S5 + S6) (See DVD 2)

Figure 7.42 shows the area of S5 + S6 resection. For this resection (Fig. 7.43a–c), the same procedure as that used for S5 resection is done first. After the dissection of the left side of area S5 is finished, liver dissection is done along the right segmental branch. This is followed by the procedure for an S6 resection.

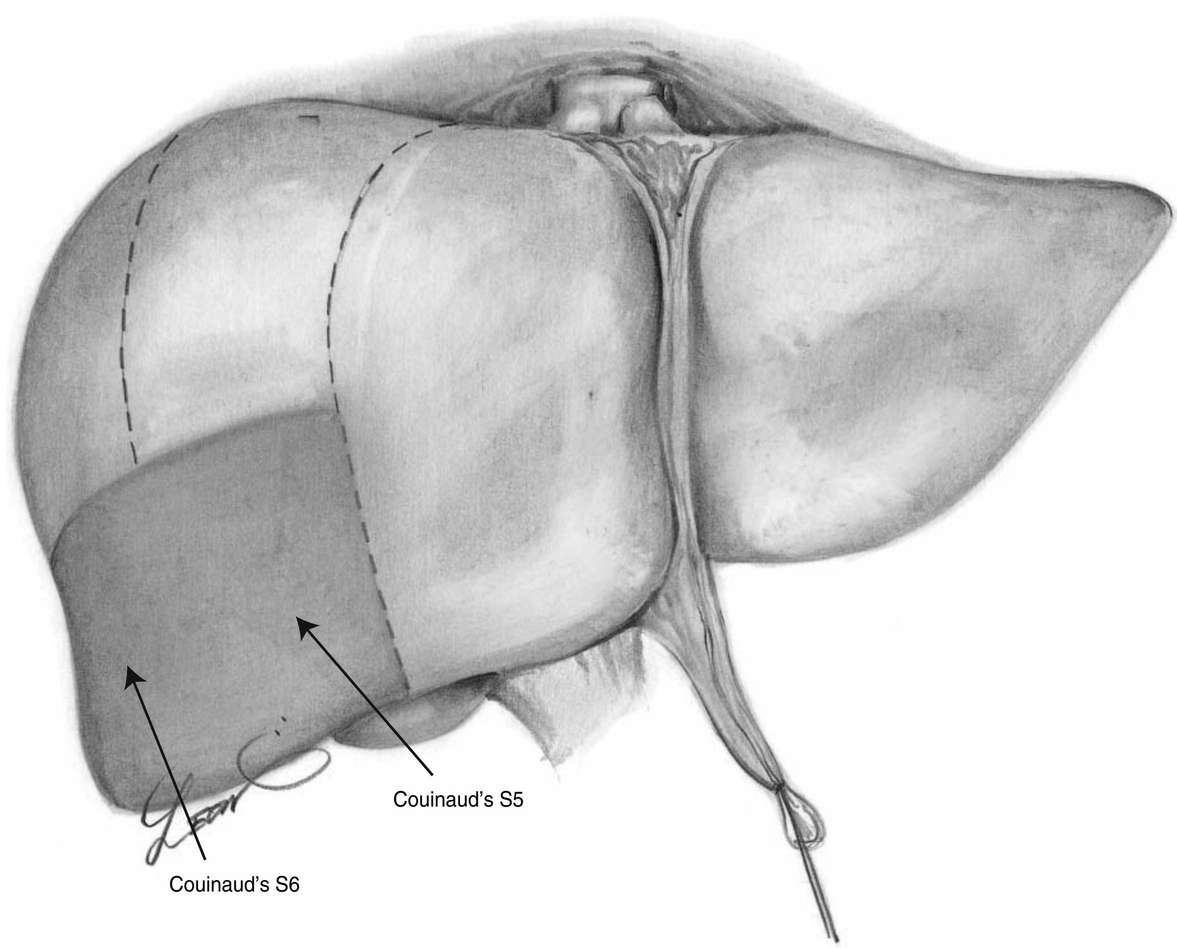


Fig. 7.42. Couinaud's S5 plus S6

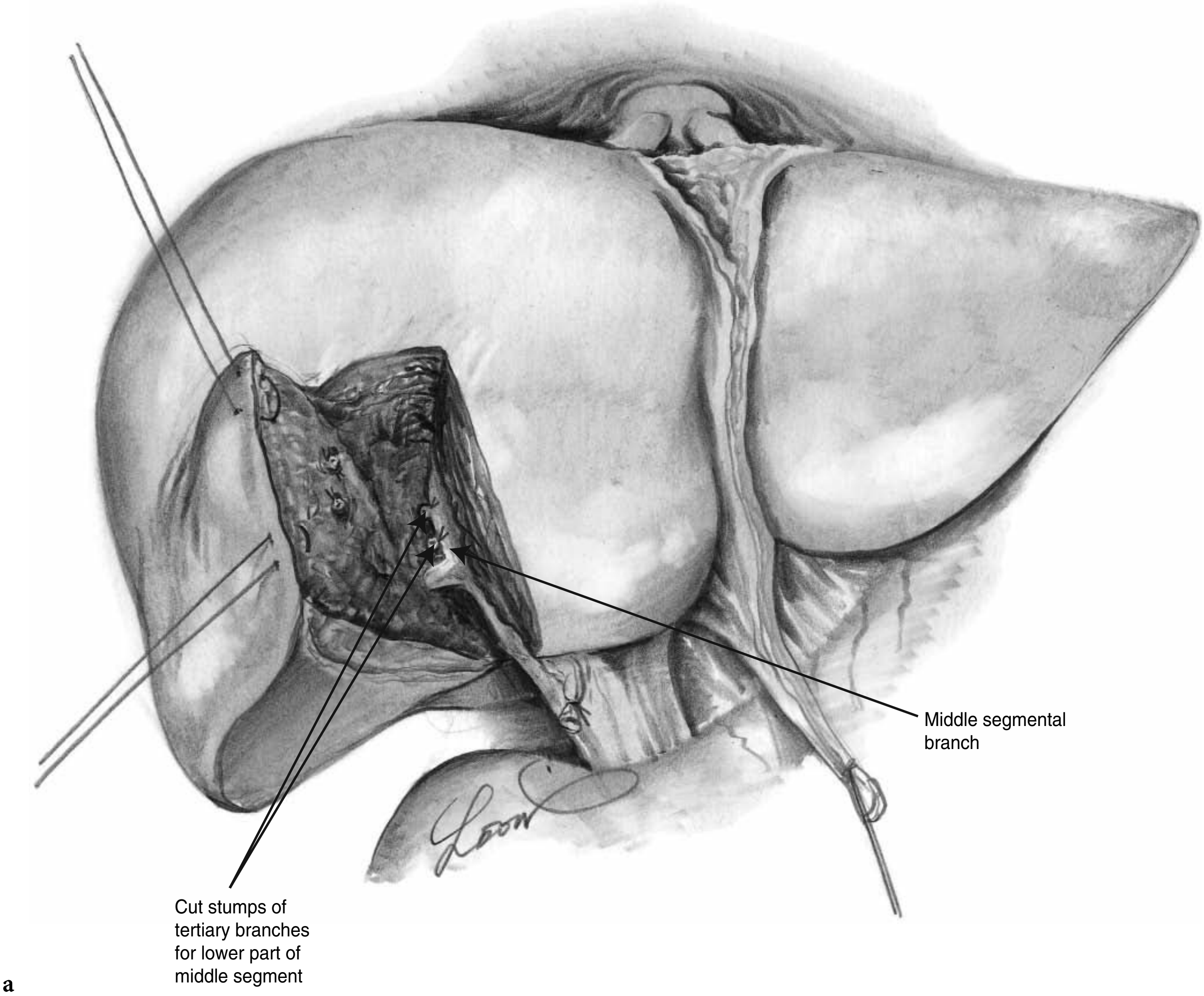


Fig. 7.43a–c. Procedure for resection of Couinaud's S5 plus S6. **a** First, middle segmental branch is temporarily clamped to confirm the intersegmental plane between middle and right segments. Several centimeters of liver parenchymal dissection is done from food side of the liver, reaching the main trunk of middle segmental branch

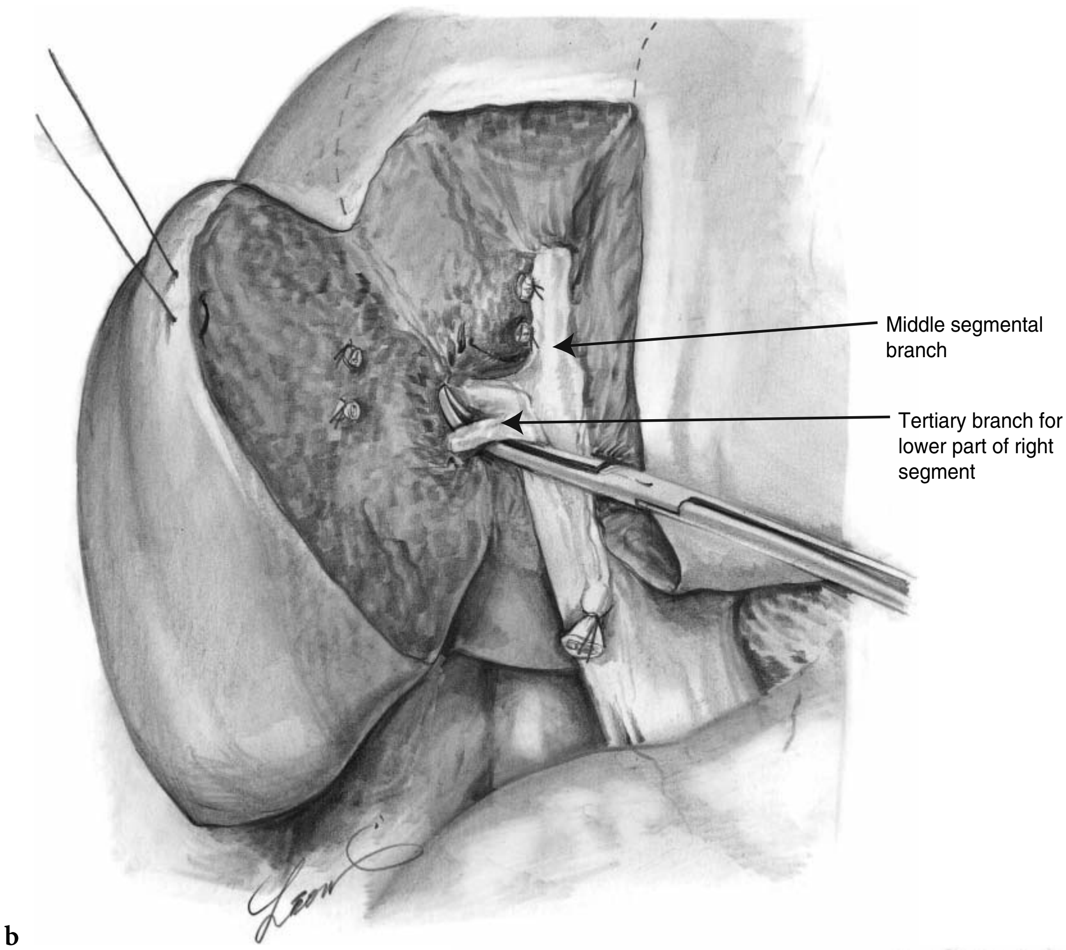


Fig. 7.43b. After transecting some tertiary branches of middle segmental branch, liver parenchymal dissection along the right segmental branch must be done

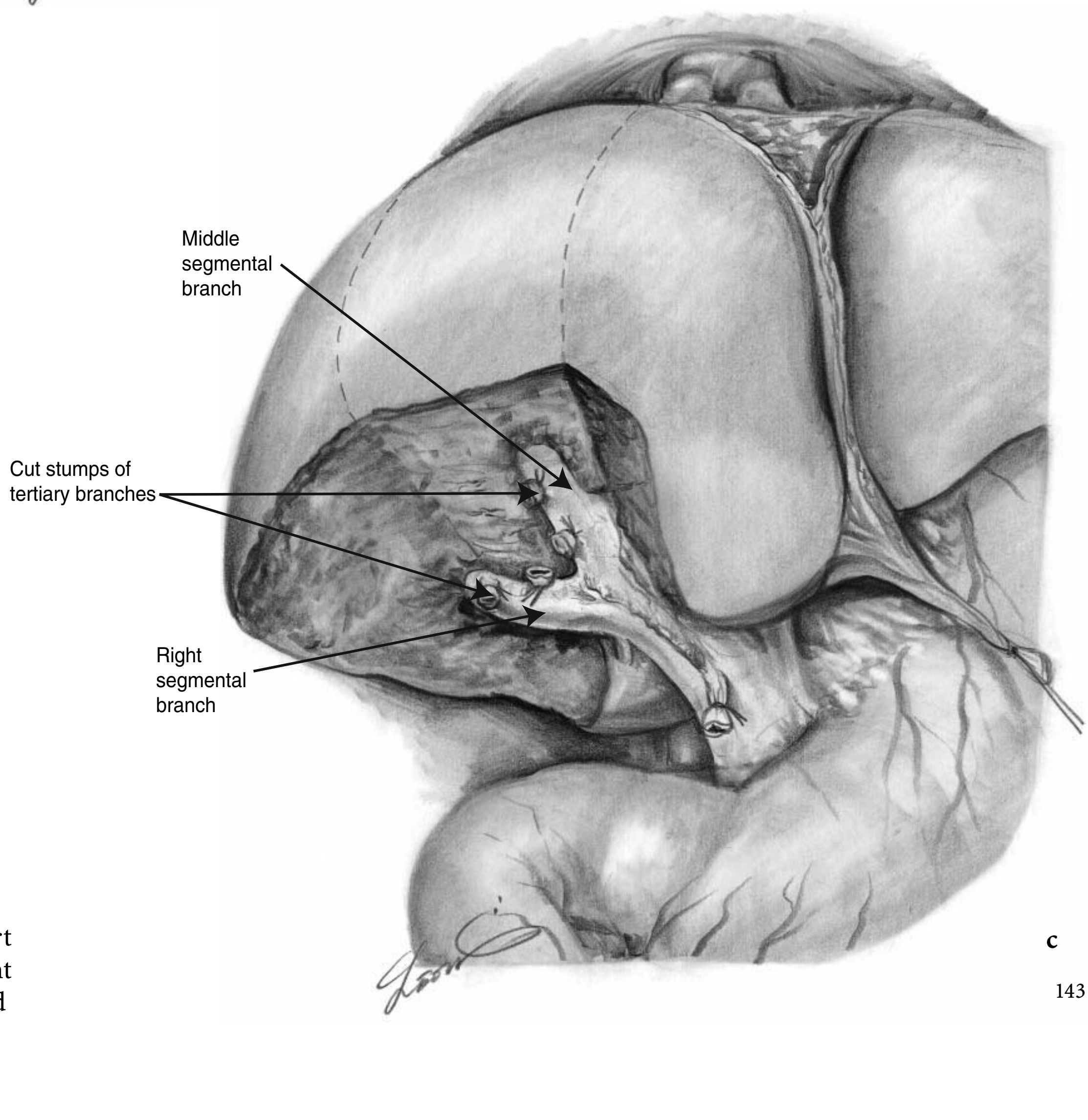


Fig. 7.43c. Lower part of middle and right segments is completed

Appendix: A History of Challenges Faced in Hepatic Surgery (2000 Cases of Hepatic Resection for HCC)

We carried out more than 2000 hepatic resections for hepatocelluair carcinoma (HCC) over a 30-year period at the Institute of Gastroenterology of Tokyo Women's Medical University, Tokyo, Japan

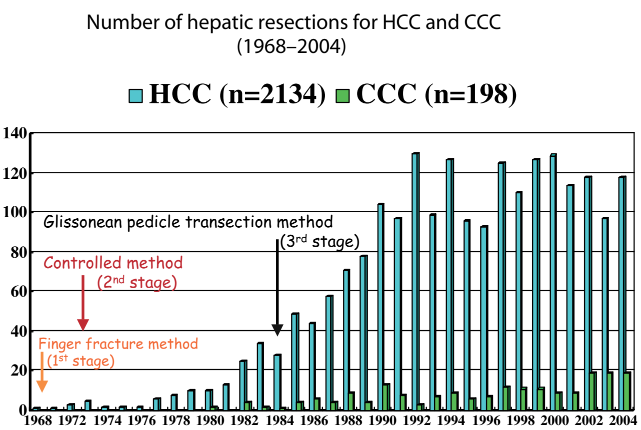


Fig. 1. At the first stage, the finger fracture method was used. At the second stage, the controlled method was introduced. In 1984, the Glissonean pedicle transection method (the third stage) went into use. Since that time and continuing up to the present, this method has been used for all hepatic resections

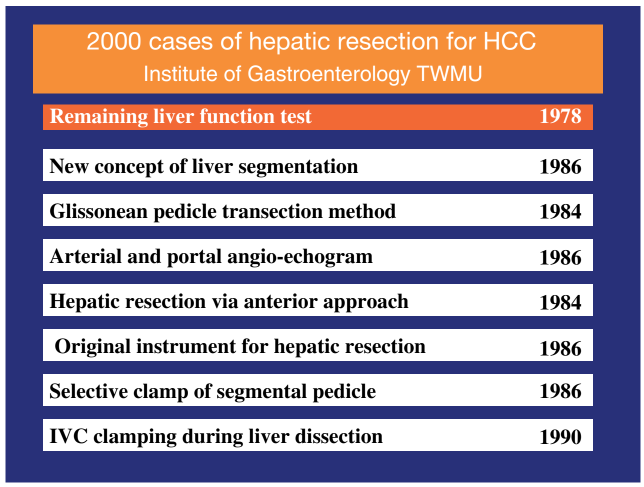


Fig. 2. Many problems had to be solved in order to perform hepatic resection safely. During the past 40 years, we have developed ideas and devices to make the operation safer and easier to carry out

Estimating liver function remaining after hepatic resection

It is now believed that 70% of hepatic volume can be resected without impairing postoperative liver function. However, most HCC cases are complicated by chronic hepatitis or liver cirrhosis, and in those cases even a small volume of hepatic resection carries with it the risk of postoperative liver insufficiency. Therefore it is necessary to know the allowable range of hepatic resection on the basis of the degree of liver damage.

What amount of remaining liver function is necessary to prevent postoperative liver insufficiency?

To make this determination, the postoperative courses of patients who had undergone hepatic resection were studied. I concluded that in cases of chronic hepatitis or liver cirrhosis, 40% of ICGR15 (indocyanine green retention rate at 15 min) is necessary to prevent postoperative liver failure. But in cases of chronic hepatitis that are not so severe fibrosis, because of rapid liver regeneration, there is no problem even if the postoperative ICGR15 value is 50%.

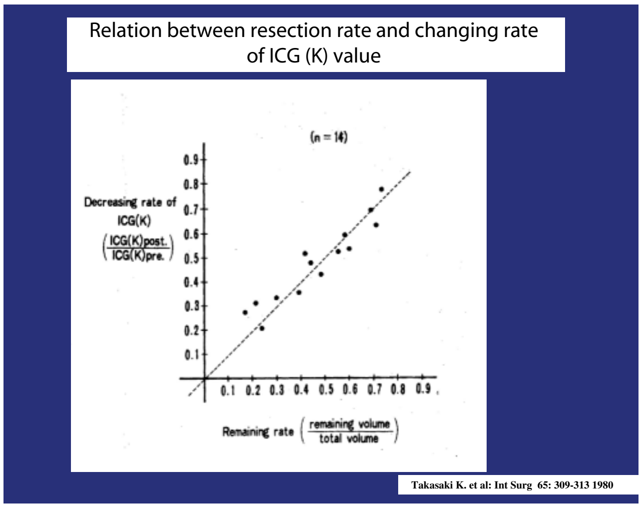


Fig. 3. I devised a method to determine the relation of the resected liver volume and the postoperative remaining liver function. I saw that the ratio of the resected liver volume is in direct proportion to the change in the ICGK (plasma clearance rate of indocyanine green) pre- and postoperatively in animal experiments

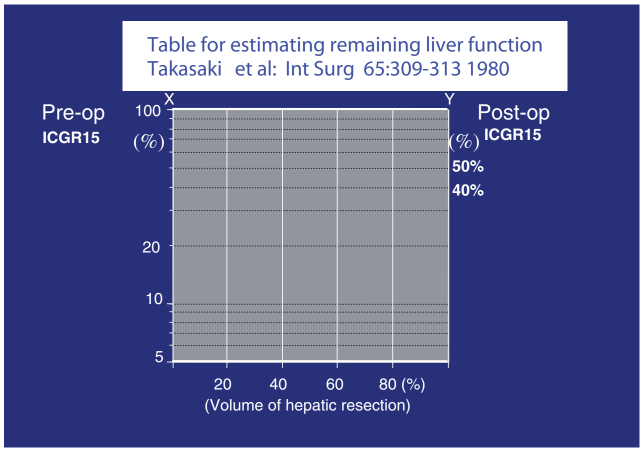


Fig. 4. With this grid, which has two vertical axis (*X* and *Y*), remaining liver function can be determined by charting ICGR15. The ICGR15 value is plotted on the X vertical axis and is connected by a *straight line* to the 100% point on the Y vertical axis. The relation of resected liver volume and remaining liver function is shown by the ICGR15 value on the Y vertical axis

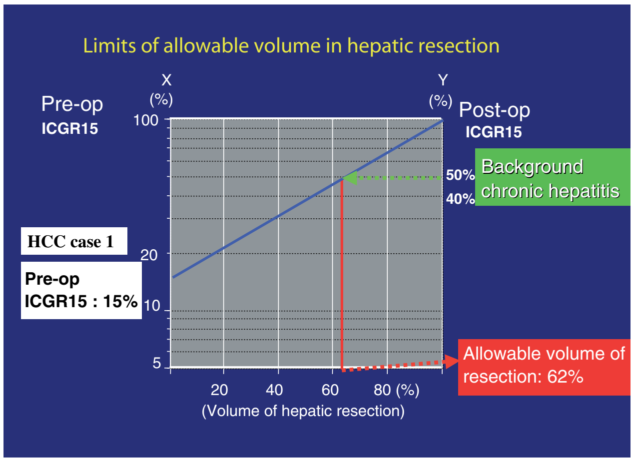


Fig. 5. Clinical case 1. The preoperative ICGR15 was 15%; the background condition of the liver was chronic hepatitis. In this case, remaining liver function had to be at least 50% of ICGR15 to prevent postoperative liver failure. The 15% point on the X vertical axis is connected with a *straight blue line* to the 100% point on the Y vertical axis. The intersection of this line and the 50% point of ICGR15 indicates the volume of hepatic resection (*solid red vertical line*). In this case, the allowable range of hepatic resection was 62%. The resection procedure therefore had to be controlled so as not to exceed a resected liver volume of 62%, in order to prevent postoperative liver failure

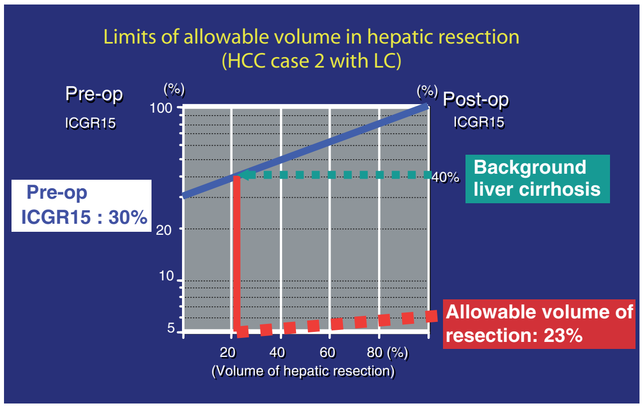


Fig. 6. Clinical case 2. Liver cirrhosis was a background complication in this case. Because regeneration after resection could not be expected, 40% of ICGR15 had to be preserved. The preoperative ICGR15 was 30%. That point on the X vertical axis is connected by a *straight line* (*blue*) to the 100% point on the Y vertical axis. The *red line* drawn vertically from the intersection of the *blue line* and the 40% point on the Y vertical axis indicate that the maximum allowable volume of hepatic resection is 23%. The resection procedure therefore had to be controlled so as not to exceed a resected liver volume of 23%

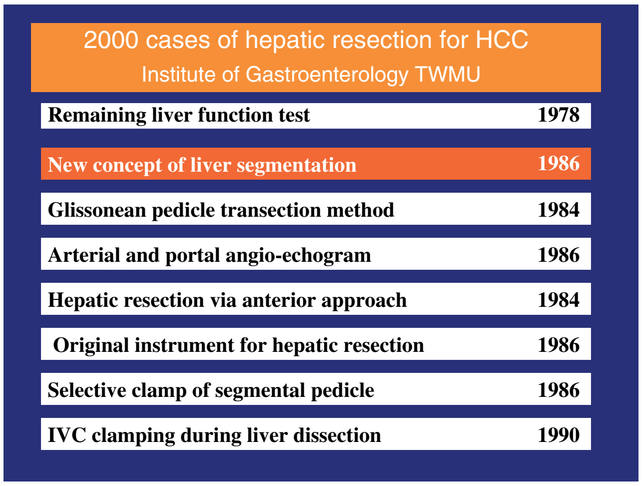


Fig. 7. In 1986, I proposed a new concept of liver segmentation based on the bifurcation patterns of Glissonean pedicles

Fig. 8. Removal of surrounding liver parenchyma from Glissonean pedicle branches using a Cavitron ultrasonic aspirator (CUSA) exposes the pedicle tree

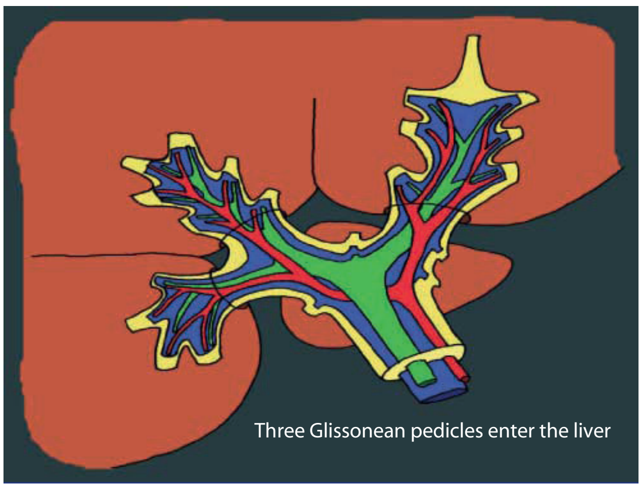


Fig. 9. The structure of the Glissonean pedicle tree inside the liver is shown schematically. The artery, portal vein, and bile duct are not visible, as they are sheathed within the fibroid bundle

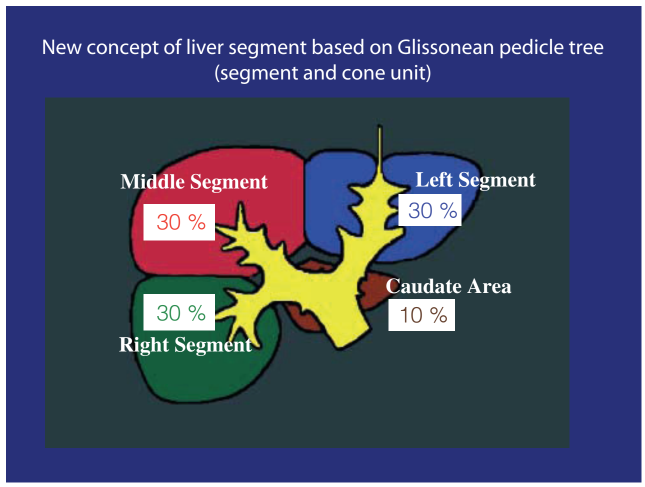


Fig. 10. The new concept of liver segmentation, based on the Glissonean pedicle tree. The three branches of the tree enter the *right*, *middle*, and *left segments* of the liver, each segment representing 30% of total liver volume, with the remaining 10% being taken up by the *caudate area*

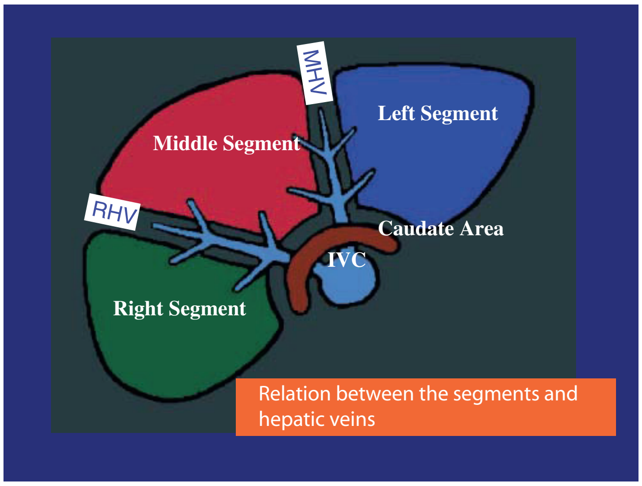


Fig. 11. Relation between the liver segments and hepatic veins. The middle hepatic vein (*MHV*) lies *between the left and middle segments*; the right hepatic vein (*RHV*) *between the middle and right segments*

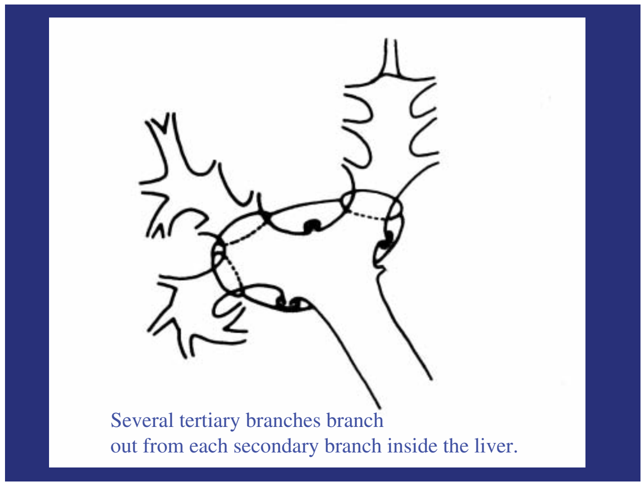
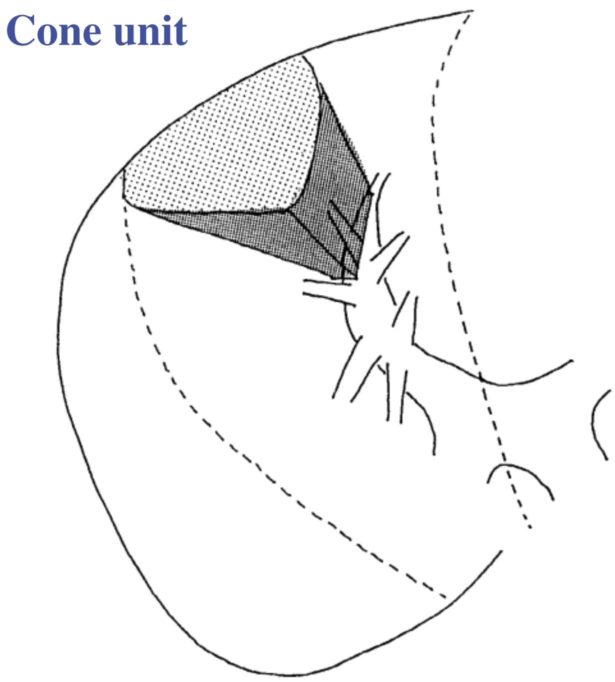
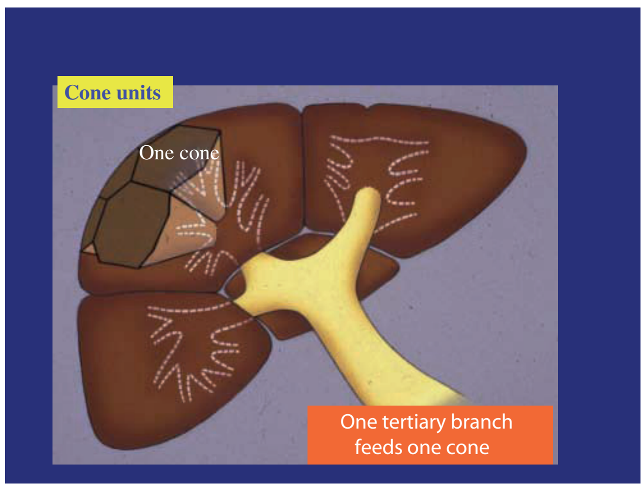


Fig. 12. The ramification pattern of tertiary branches from secondary branches varies from patient to patient, typically ranging from two to eight branches

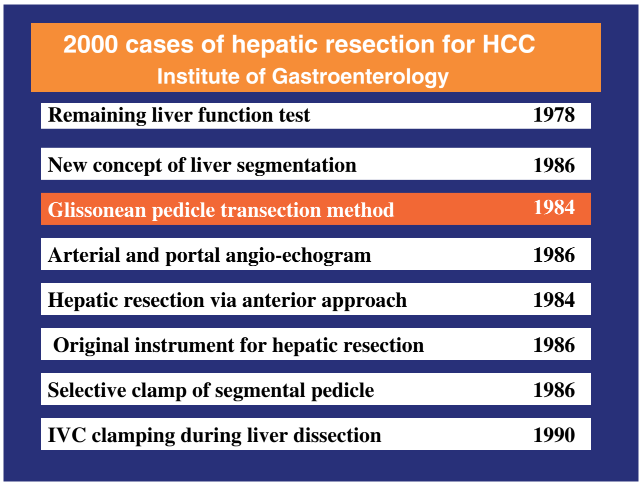


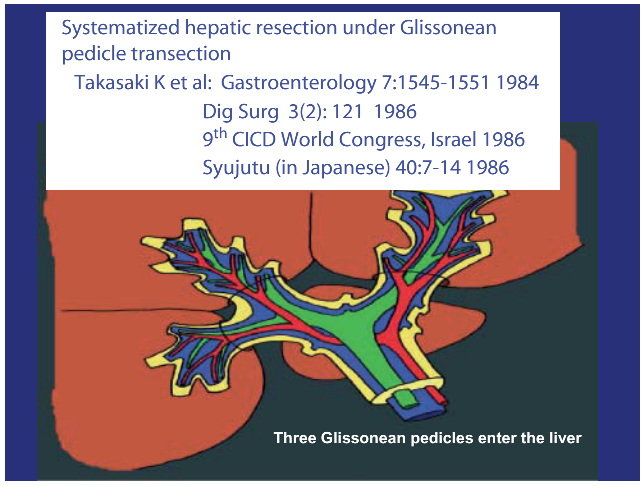


14

13 One tertiary branch feeds a cone-shaped area.

Figs. 13, 14. Each tertiary branch feeds one cone-shaped area, hereafter referred to as a *cone unit*

15 

 16

Figs. 15, 16. My new procedure for hepatic resection, the Glissonean pedicle transection method, was first performed in 1984

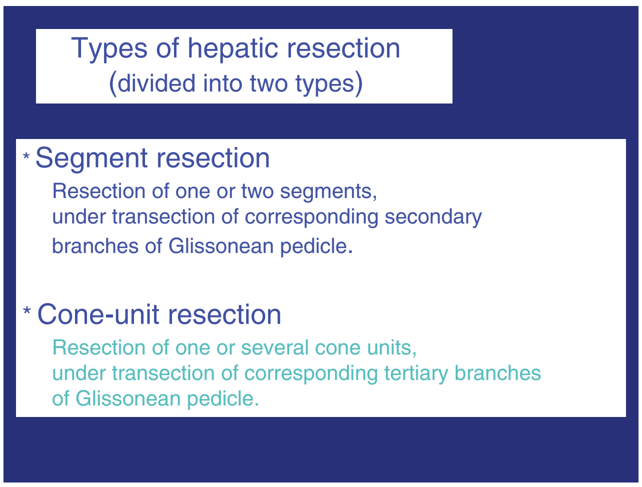
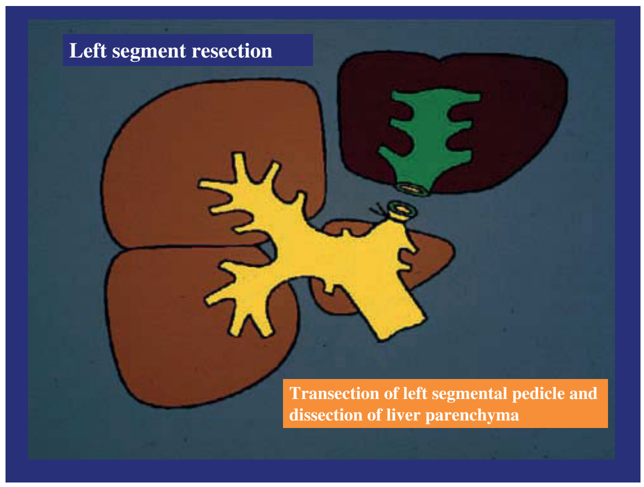


Fig. 17. There are two types of hepatic resection procedure: segment resection and cone unit resection



Figs. 18–25. Segment resection is performed by transecting a segmental branch at the hilus of the liver and resecting the area in which that that branch is distributed

Fig. 18. Schematic diagram of left segment resection, showing transection of the left segmental pedicle and dissection of liver parenchyma

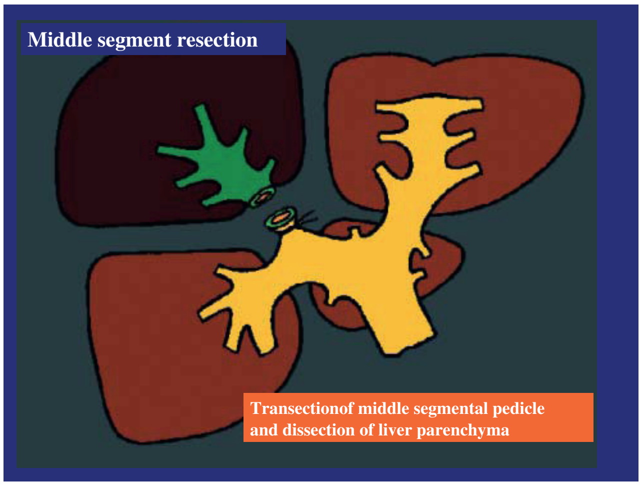


Fig. 19. Schematic diagram of middle segment resection, showing transection of the middle segmental pedicle and dissection of liver parenchyma

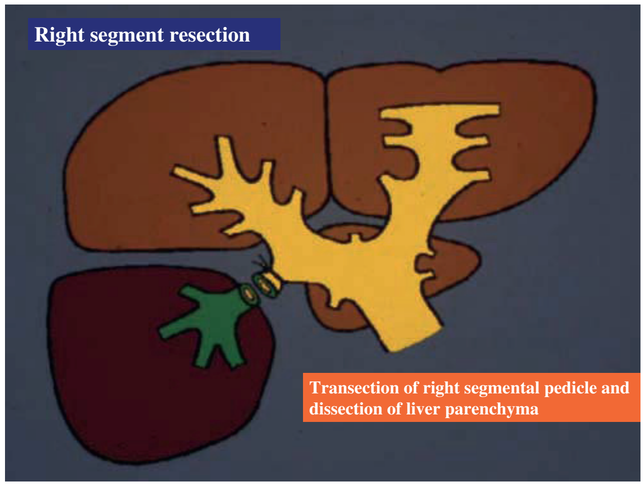


Fig. 20. Schematic diagram of right segment resection, showing transection of the right segmental pedicle and dissection of liver parenchyma

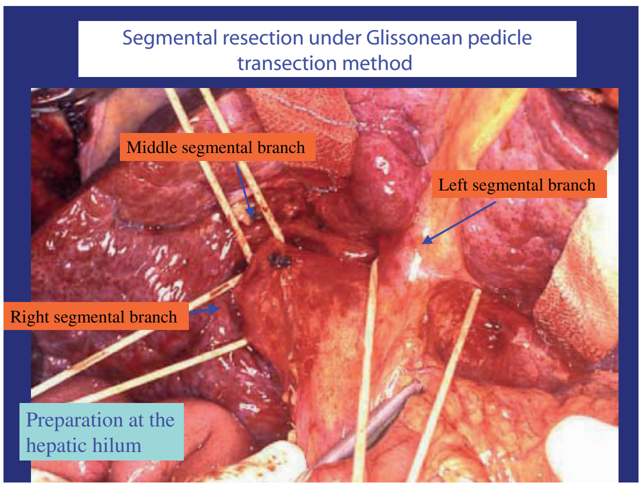


Fig. 21. Intraoperative photograph showing preparation at the hepatic hilum for segmental resection. The *right*, *middle*, and *left segmental branches* are identified

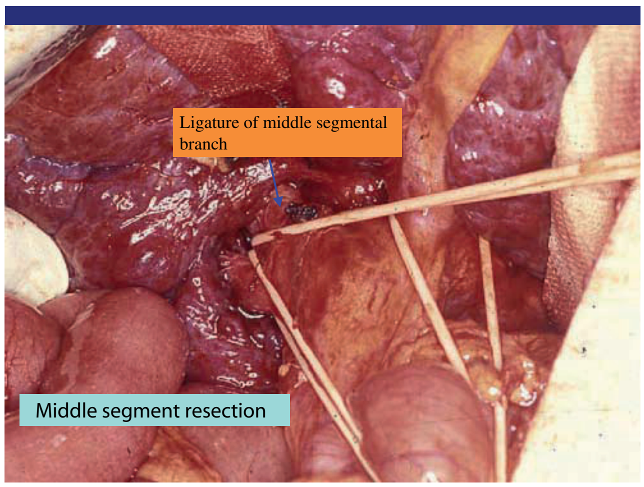


Fig. 22. Intraoperative photograph of middle segment resection, with the *ligature of the middle segmental branch* indentified

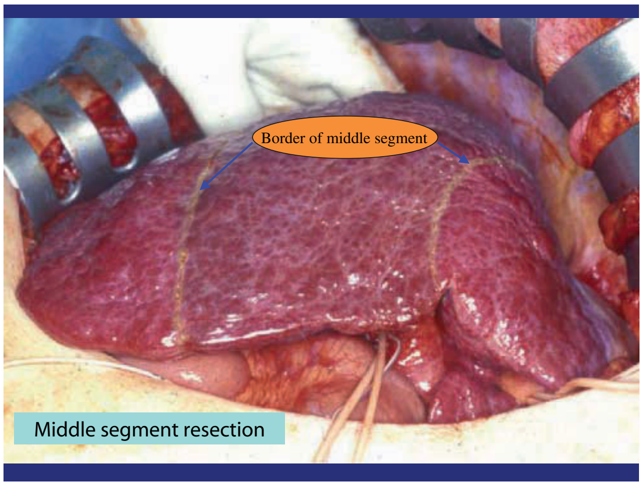


Fig. 23. The *borders of the middle segment* are shown by a change of color

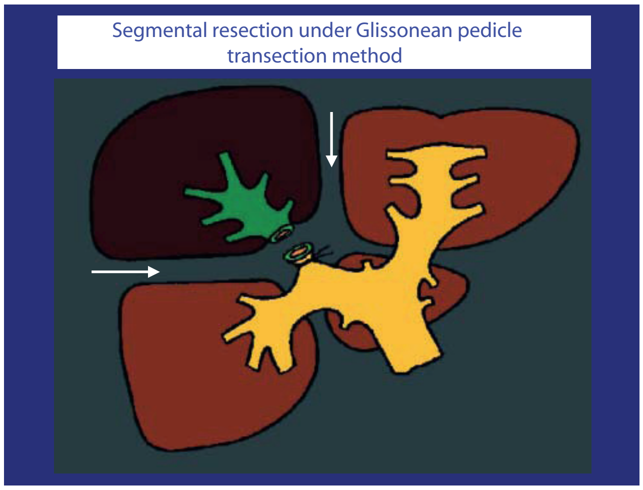


Fig. 24. Liver parenchymal dissection was done on both demarcated lines

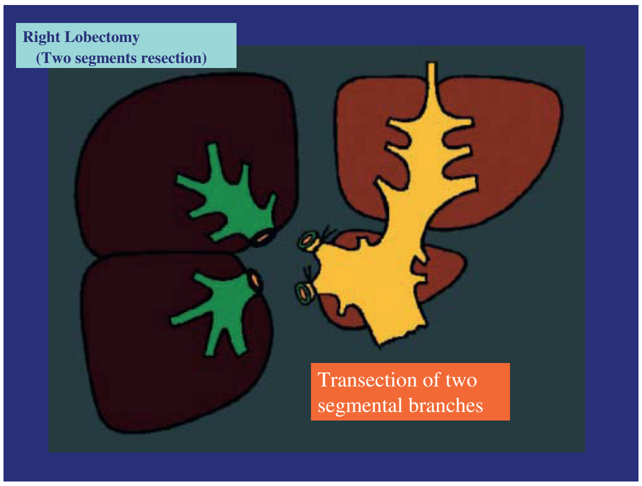


Fig. 25. In the case of a right lobectomy, both the right and middle segmental branches must be transected

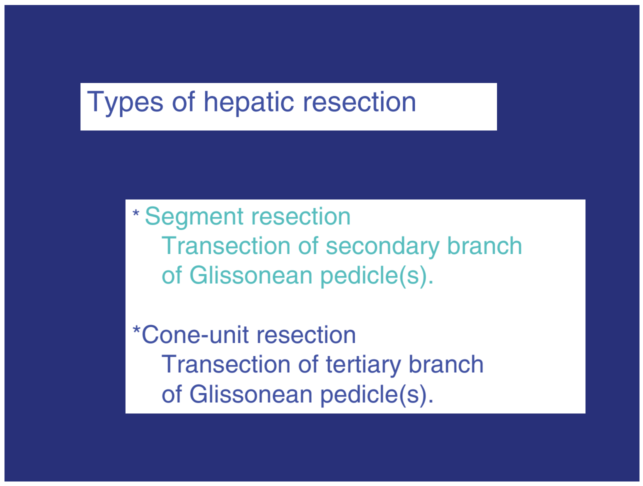


Fig. 26. For cone unit resection, transect one or more tertiary branches and resect the cone units that feed off those branches

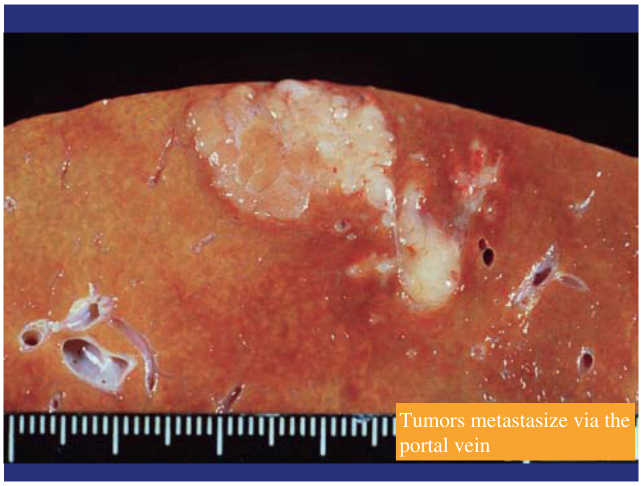


Fig. 27. Even in cases of small HCC, tumors sometimes grow and spread throughout the liver via the portal vein

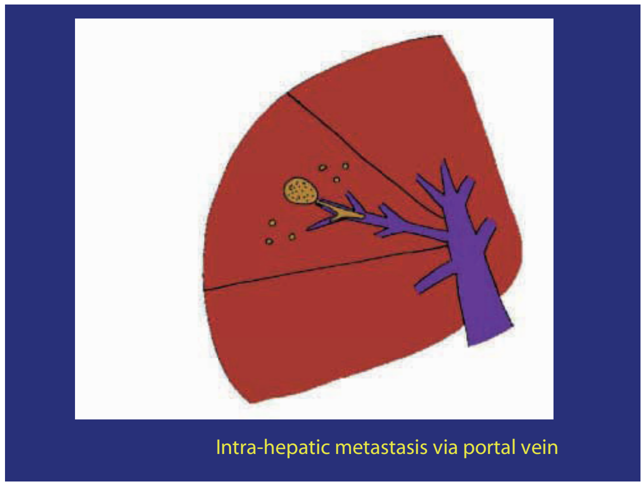


Fig. 28. Schema of intrahepatic tumor metastasis via the portal vein

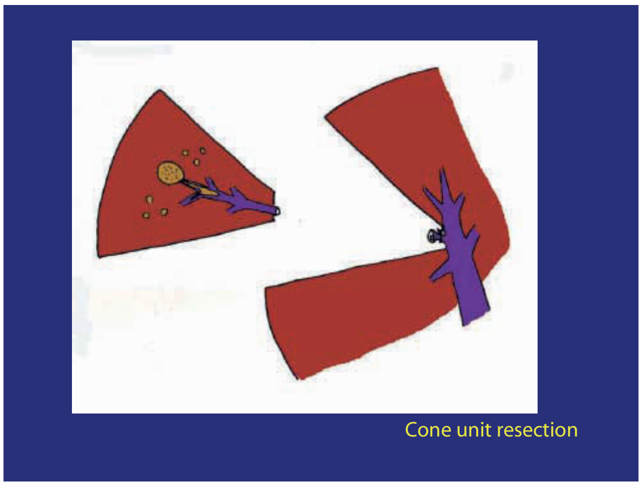
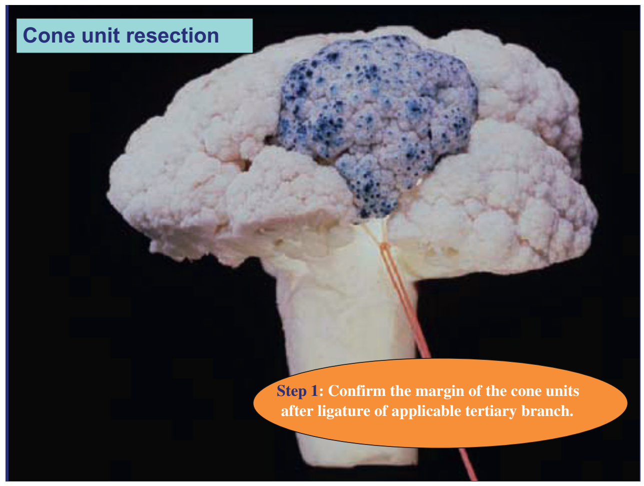


Fig. 29. Schema of cone unit resection



30

Figs. 30–32. Cone unit resection, with a cauliflower head as an illustrative model. Steps 1, 2, and 3 are illustrated

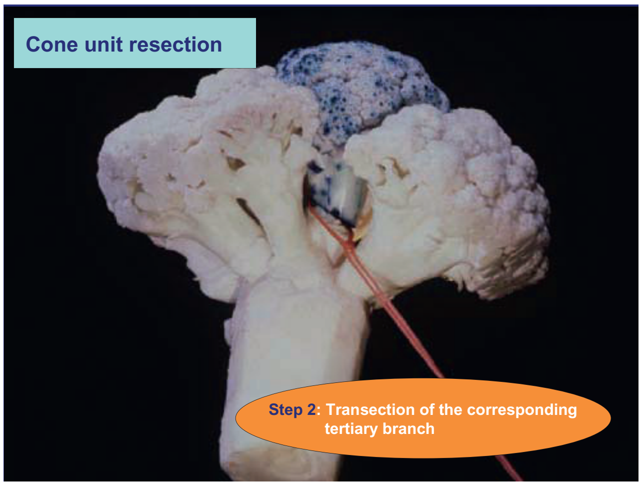


Fig. 31. Step 2

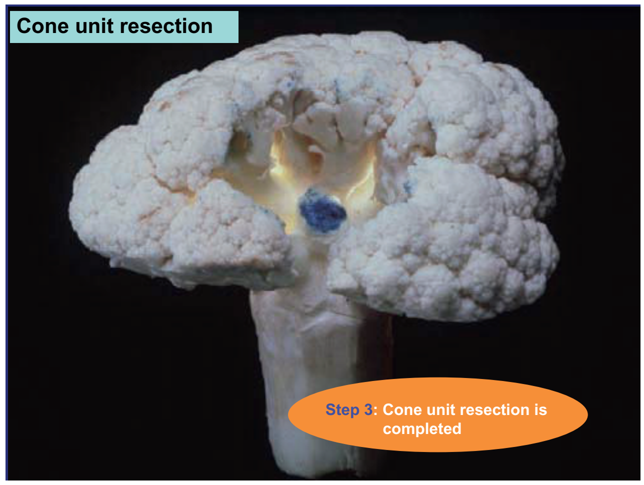


Fig. 32. Step 3

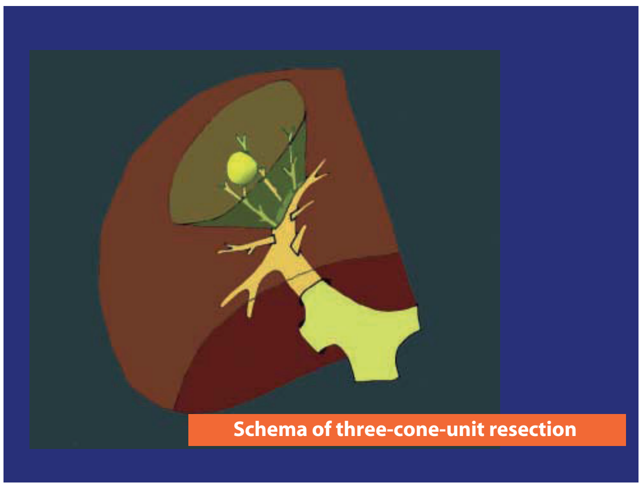


Fig. 33. Schema of cone units resection

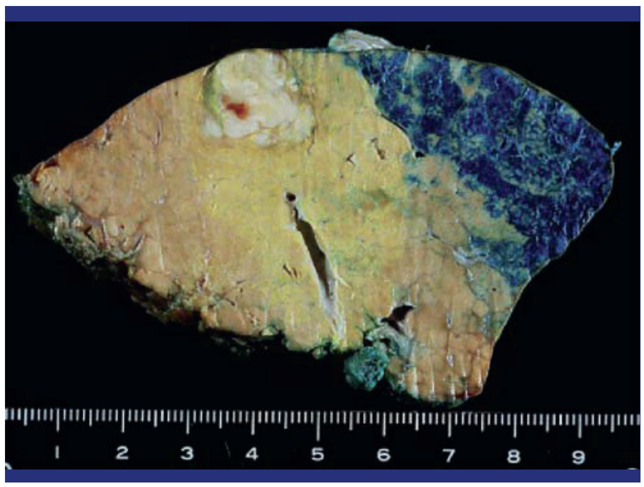


Fig. 34. Following the transection of applicable tertiary branches, liver parenchyma is dissected along the *liens* indicated. Resected cone units specimen

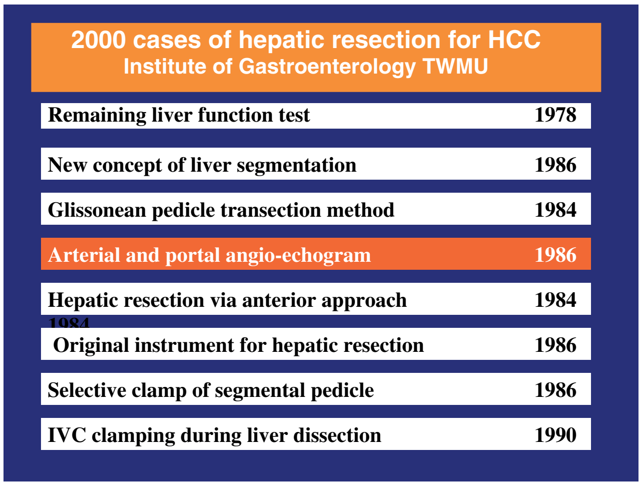


Fig. 35. When dealing with small tumors, it is difficult to determine in which branch they lie. I developed the arterial and portal angio-echogram in 1986 to address this problem

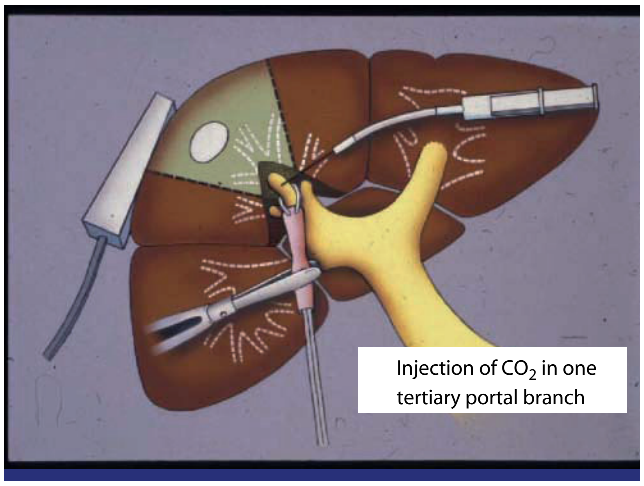


Fig. 36. CO_2 is injected into the portal vein, which on an echogram enhances the area fed by the vein. Tumors, however, are not enhanced

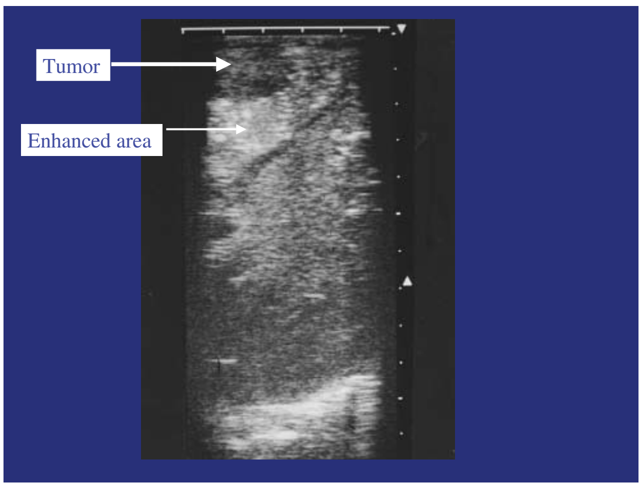
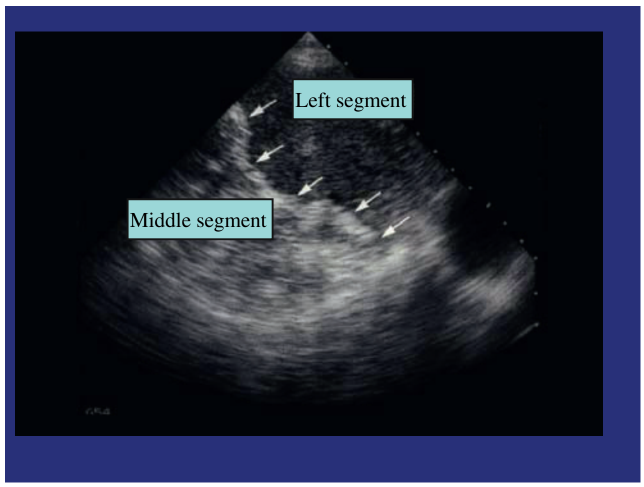
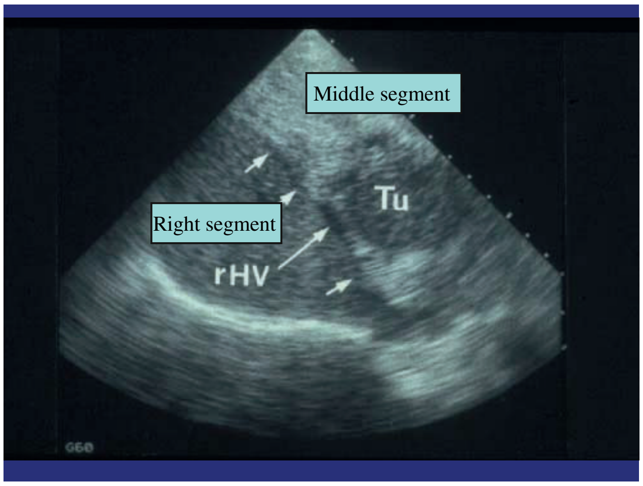


Fig. 37. Echogram showing that the *tumor* (*upper left*) lies just outside the *enhanced area*. The punctured branch was confirmed to be a cancer-bearing portal branch



38

Figs. 38, 39. In echograms, the intersegmental planes (*arrows*) are clearly shown after injection of CO_2 gas into the middle segmental branch of portal vein. *rHv*, right hepatic vein; *Tu*, tumor



39

Figs. 38,39. *Continued*

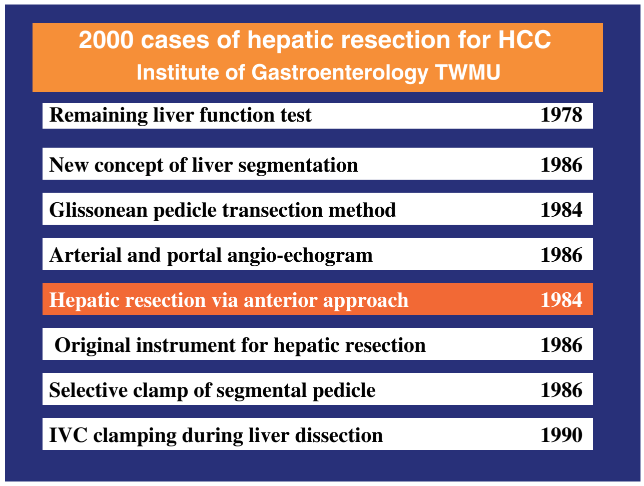


Fig. 40. For dealing with large tumors, in 1984 I developed the anterior approach for hepatic resection

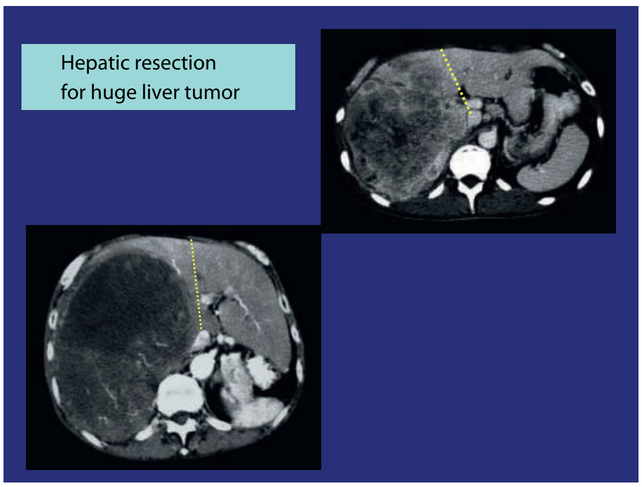


Fig. 41. With large tumors, there is some risk of bleeding and intravascular dissemination of cancer cells at the time of hepatic mobilization. For this type of case, transection of liver parenchyma is done along a line (*dotted line*) from the anterior surface to the interior vena cava (IVC)

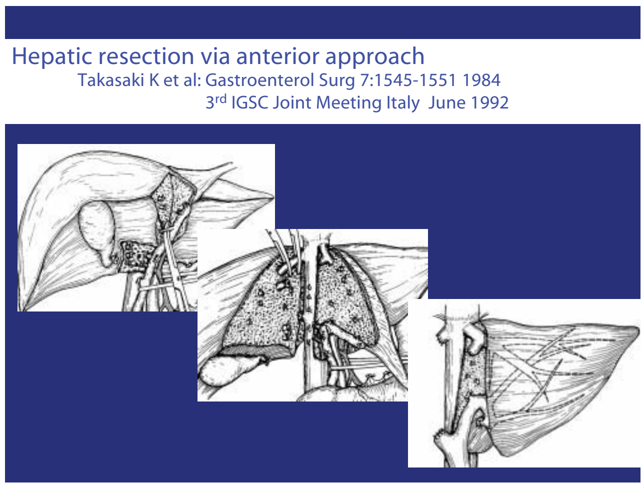
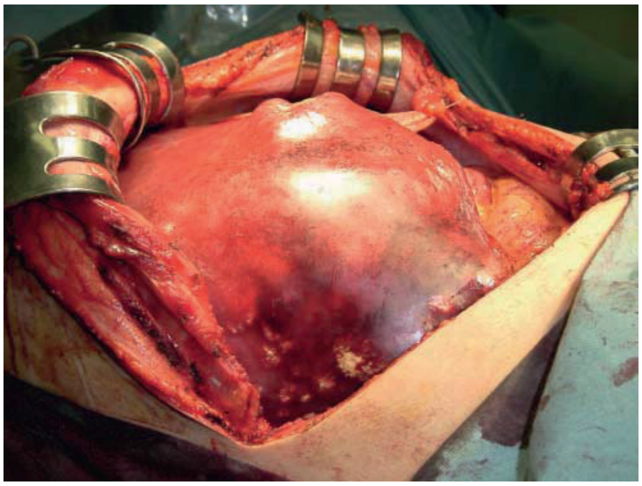
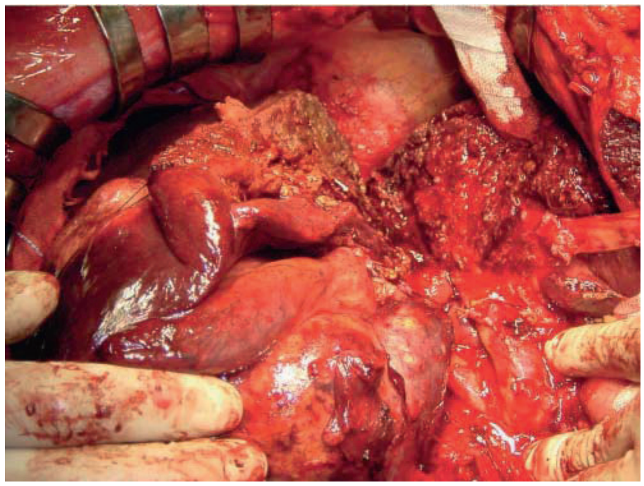
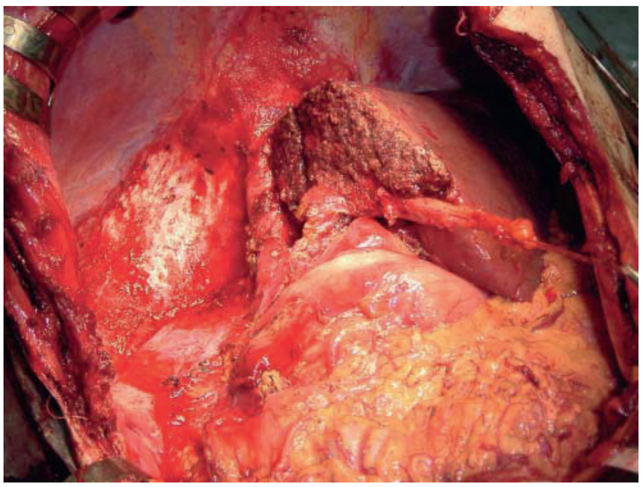


Fig. 42. Schematic illustration on hepatic resection via the anterior approach

43



44

Figs. 43–45. A clinical case of large HCC, which occupied the entire area of the right lobe and the medial area of the left segment. After transection of the Glissonean pedicles at the hepatic hilus, liver parenchyma is dissected from the ventral to the dorsal side. The IVC can be seen at the dorsal end of the cut surface

45


Figs. 43–45. *Continued*

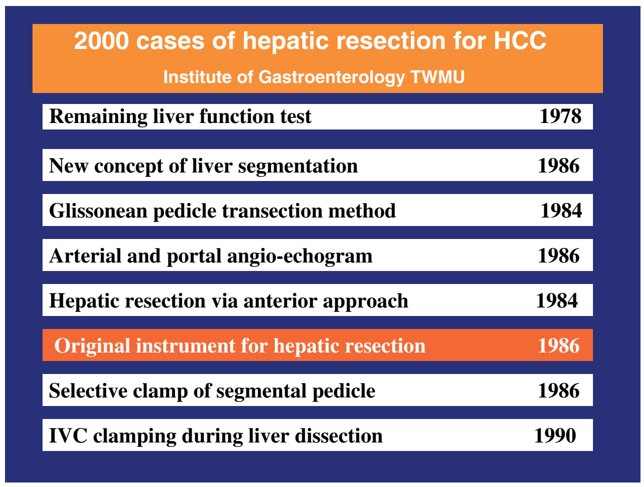


Fig. 46. The year 1986 saw the development of several original instruments for hepatic resection

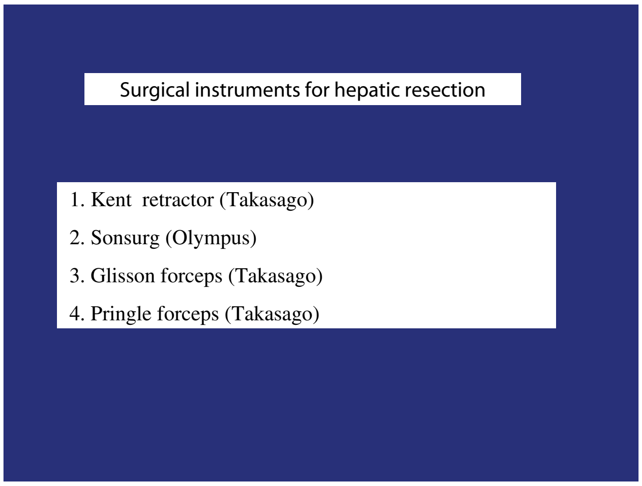


Fig. 47. I devised 4 kinds of surgical instruments for my precedure

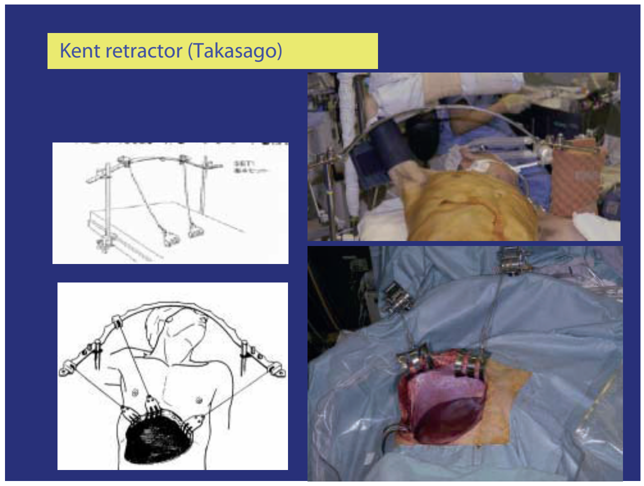


Fig. 48. Kent retractor. A costal arch is pulled up by hooks suspended from the arched bar, thus improving operative views

Fig. 49. Sono Surg (Olympus). By fitting an electric coagulation function to an ultrasonic histotripsy device, liver-cutting performance in cases of cirrhosis was improved

Fig. 50. Pringle forceps. These are used to gently interrupt blood flow in the porta hepatis

Fig. 51. Glisson forceps. Glisson forceps are used to tape a Glissonean pedicle at the hepatic hilus

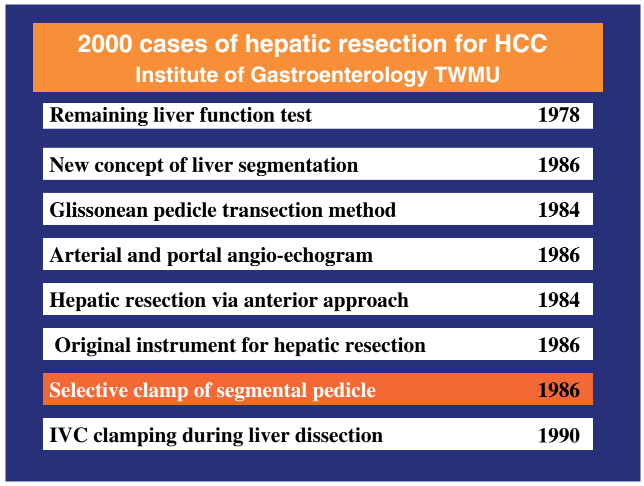
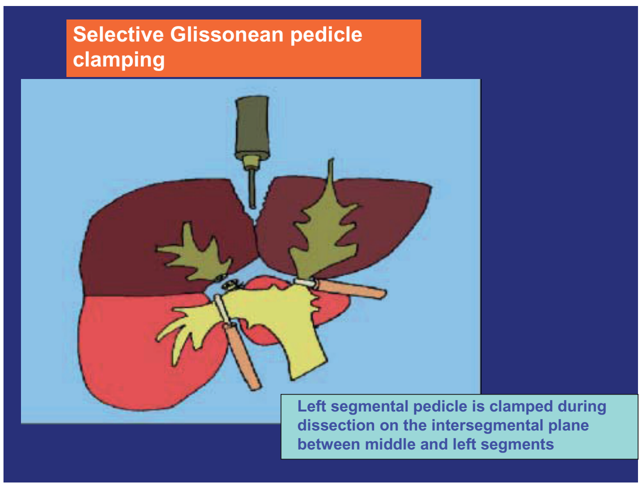
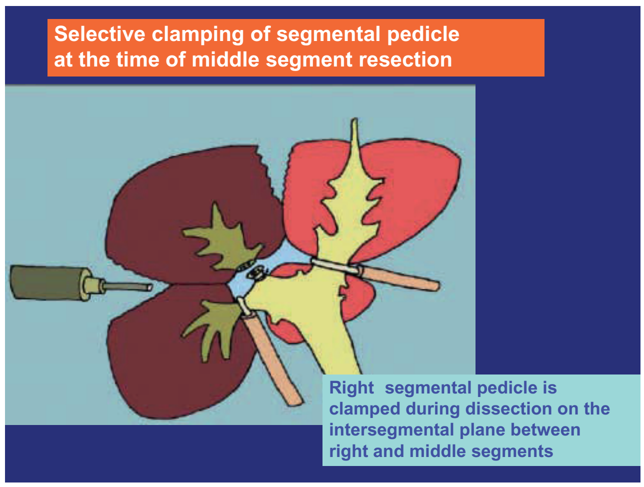


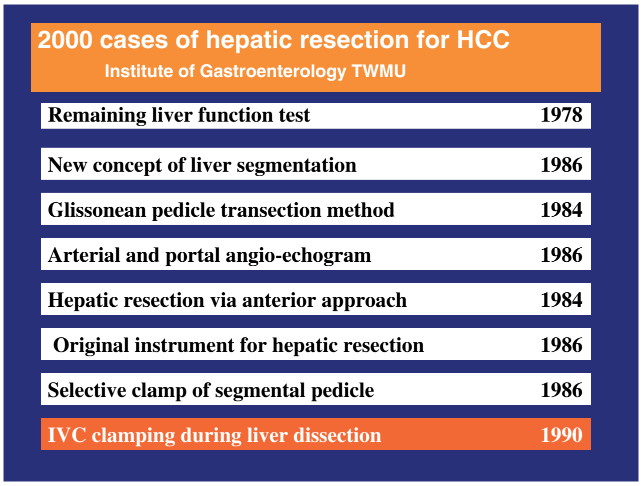
Fig. 52. Control of bleeding during the operation can be achieved by selective intermittent clamping of portal blood flow in cases of severe liver cirrhosis

53


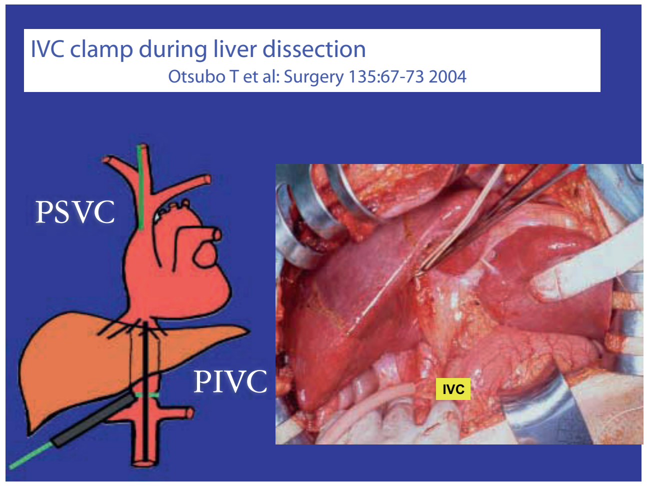


54

Figs. 53, 54. At the time of middle segment resection, the middle segment Glissonean pedicle is first transected. During parenchyma dissection on the intersegmental plane between the middle and left segments, the left segmental branch of the Glissonean pedicle is temporarily clamped. After 10 min, the clamp is switched to the right segmental branch and parenchyma dissection on the intersegmental plane between the right and middle segments is performed

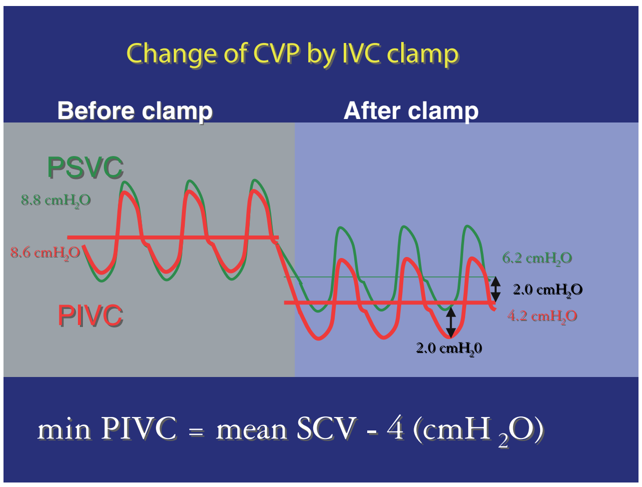


55



56

Figs. 55–57. Clamping of the inferior vena cava at the food side of the liver reduces central venous pressure by almost 4 cm on average



57

Figs. 55–57. *Continued*

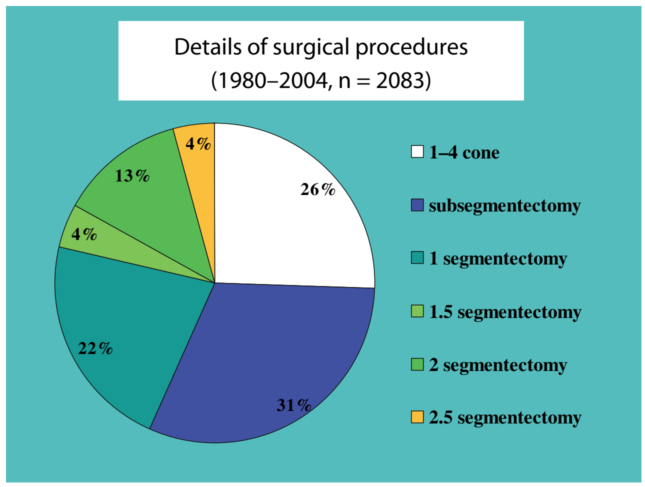


Fig. 58. Details of procedures of hepatic resection. 97% of the cases were complicated with liver cirrhosis or chronic hepatitis. 57% of the cases of resection were smaller than one segment resection

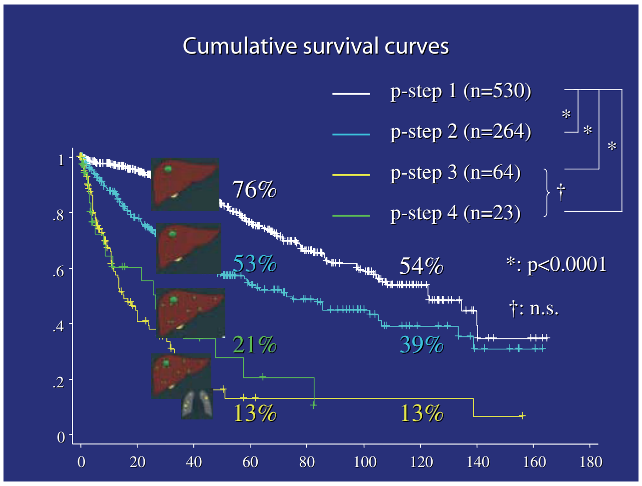


Fig. 59. Results after hepatic resection for HCC in recent cases. 63% of all operated patients were alive 5 years after operation and 44% of patients were alive after 10 years. In cases of simple nodular type (step 1), without regard to size, 5-year and 10-year survival rates are 76% and 54%, respectively. Even in cases of simple nodular extranodular growth type, 5-year and 10-year survival rates are 53% and 39%. These results are almost 20% better than those of other institutes. I believe that systematized hepatic resection must be a reasonable procedure for HCC treatment

References

Ariizumi S, Takasaki K, Yamamoto M, et al (2000) Multicrntric hepatocellular carcinomas tend to grow in more damaged segments of the liver. J Gastroenterol 35:441–444

Couinaud C (1954) Lobes et segments hepatiques. Press Med 62:709–712

Healey Jr, JE, Schroy PC (1953) Anatomy of the biliary ducts within the human liver. Analysis of the prevailing pattern of branchings and the major variations of the biliary ducts. Arch Surg 66:599–616

Lin TY (1958) Study on lobectomy of the liver. A new technical suggestion on hemihepatectomy and report of three cases of primary hepatoma treated with total left lobectomy of the liver. J Formosasn Med Assoc 57:742–761

Makuuchi M, Hasegawa H, Yamazaki S (1985) Ultrasonically guided subsegmentectomy. SGO 161:346–350

Miyazaki S, Takasaki K, Yamamoto M, et al (1999) Liver regeneration and restoration of liver function after partial hepatectomy: The relation of fibrosis of the liver parenchyma. Hepato-Gastroenterology 46:2919–2924

Otsubo T, Takasaki K, et al (2004) IVC clamp during liver dissection. Surgery 135:67–73

Takasaki K (1978) Development of a method of estimating postoperative hepatic functions upon hepatectomy before the operation (in Japanese). Nihon Geka Gakkai Zasshi 79:1526–1534

Takasaki K (1986) Selection of operative procedure for hepatocellular carcinoma complicated with liver cirrhosis (in Japanese). Nihon Syokaki Geka Gakkai Zasshi 19:1881–1889

Takasaki K et al (1984) Extended right lobectomy for big hepatoma in right lobe: aimed non touch isolation (in Japanese). Syokaki Geka 7:1545–1551

Takasaki K et al (1990) Highly anatomically systematized hepatic resection with Glissonean sheath code transection at the hepatic hilus. Int Surg 75:73–77

Takasaki K et al (1992) Hepatic resection via anterior approach. Proceedings of the 3rd IGSC joint meeting. Rome

Takasaki K et al (1998) Glissonean pedicle transection method for hepatic resection: A new concept of liver segmentation. J Hepatobiliary Pancreat Surgery 5:286–291

Takasaki K, Kobayashi S, Tanaka S (1985) Concept of three segments under consideration of bifurcation pattern of Glissonean pedicle (in Japanese). In: Oota Y (ed) Progress of gastroenterology ’85. Nihon Igakkan, Tokyo, pp 47–48

Takasaki K, Kobayashi S, Tanaka S (1986) Highly systematized hepatic resection by Glissonean sheath- transection method. Proceedings of 9th CICD world congress (Dig Surg 3:121). Tel Aviv

Takasaki K, Kobayashi S, Tanaka S, Mutou H, Watayo T, Saito A, Ageta T, Shimada Y, Tanaka T, Honda H (1985) New developed systematized hepatectomy by Glissonean pedicle transection method (in Japanese). Syujutu 40: 7–14

Takasaki K, Kobayashi S, Suzuki S, et al (1980) Predetermining postoperative hepatic function for hepatectomies. Int Surg 65:309–314

Takasaki K, Saito A, Nakagawa M, et al (1986) Enhanced intraopretative ultrasonography. Advanced diagnostic method to determine tumor-bearing area in the liver by intraarterial and portal injection of carbon dioxide gas. JSUM association. Proceedings, Tokyo, pp 900–901

Ungvary GY (1977) Functional morphology of the hepatic vascular system. Akademiai Kiado Budapest

Yamamoto M, Takasaki K, Ohtsubo T, et al (2001) Effectiveness of systematized hepatectomy with Glisson's pedicle transaction at the hepatic hilus for small nodular hepatocellular carcinoma: Retrospective analysis. Surgery 130:443–448