Surgery of the Liver and Portal Circulation

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To the memory of Blanche
and
To my wife, Jane

Preface

This volume, unlike texts of multiple authorship, is intended to present the views of one individual on the complex pathophysiology of diseases of the liver and portal circulation, and the problems inherent in their surgical treatment.

The inadequacies of single authorship are obvious. Spirited controversy exists in almost all areas of pathophysiology; innumerable ingenious and satisfactory operative techniques have been developed which differ from those presented in this volume; and many experienced surgeons would disagree with proposed methods of evaluation and management. On the other hand, a series of chapters, each written by an expert, invariably results in some duplications and omissions and tends to lack continuity of thought. The ultimate objective of this volume is to provide the general surgeon with a simplified guide to management from a single point of view.

Consistent with this particular approach, the text has not been documented with endless references, but the bibliography given at the end of each chapter is intended to provide the reader with a list of valuable monographs and specific reports concerned with each particular section. The bibliography is not intended to be totally comprehensive and many excellent, provocative, and important references may be missing. If, however, the reader wishes to explore in depth any of these areas, more specific details and references can be found in the bibliography of listed texts, monographs, and reports. With the text serving as an introduction, the reader may pursue almost endlessly a chain of historical thought and current controversy, using the listed bibliography as a base.

In many sections, particularly those pertaining to surgical anatomy, and to biochemistry and pathophysiology of the liver, the text and illustrations have been kept to a minimum in the interest of avoiding a repetition of material easily available in standard, widely

utilized textbooks. It is hoped that this brevity will prove advantageous to some and will not seriously offend others who might wish for a more expanded, extensive, and documented review of all topics presented.

I would like to express my appreciation to my surgical and medical colleagues throughout the country whose clinical and laboratory investigations have done so much to clarify the problems in this area, to faculty and research fellows at the Harvard Medical School whose association over the years has been so stimulating, and to the students whose provocative questions have been the stimulus for so many of the investigations described. Miss Zelda Cushner is responsible not only for the completion and accuracy of the manuscript but has provided constant suggestions and criticisms which have served to improve immeasurably the initial effort. Jayne McGuire, Barbara Kern, and Marguerite Souza have, as always, been continuously helpful with the endless details concerned with the final text. Dr. Melvin Clouse and Dr. Herbert Gramm of the Department of Radiology at the New England Deaconess Hospital were most helpful in the preparation of the chapter on Diagnostic Techniques in Liver Surgery.

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Contents

Anatomy of the Liver and Portal Bed

CHAPTER 1

Excellent descriptions of the comparative anatomy and embryology of the liver can be found in a standard text of anatomy and embryology and in a number of existing books on the liver, particularly those of Child, Schiff and Schwartz. The details of the basic gross and microscopic anatomy are also easily available. Therefore, a detailed review of these areas would seem repetitious and unnecessary; only selected material and information that may be particularly pertinent to the problems encountered by the surgeon will be included in this chapter.

The embryologic development of the liver begins in about the fourth week in the life of the fetus when the hepatic diverticulum arises from the intradermal lining of the foregut. The tubular hepatic cords penetrate the septum transversum. Lobules develop, proliferating parenchymal cells become transformed into sinusoids, bile ductules form as centers of small parenchymal masses and ultimately the final form of the liver and its vascular and secretory apparatus takes place.

From the fifth to the seventh week of fetal development, a number of interesting changes take place in the blood flow to the fetal liver. The right omphalomesenteric vein becomes obliterated, and the left persists, developing ultimately into the main portal vein. The main flow of the umbilical vein becomes encompassed by the developing liver and shifts from the sinus venosus to the intrahepatic pathway, which becomes known as the ductus venosus. The ductus exists up to the birth of the fetus, providing a mechanism whereby oxygenated blood is carried directly to the heart; at birth, because of physiologic changes induced by respiration and a lowering of umbilical vein pressure, the ductus venosus closes off. Normally it closes off entirely, an interesting protective mechanism, which prevents any severe hemorrhage from the umbilical cord. This obliterated umbilical vein

persists in the round ligament and provides a potential mechanism for access to the portal circulation that has been exploited for diagnostic and sometimes therapeutic purposes in recent years. As will be pointed out later, this obliterated vein can usually be identified and dilated and passage into the left portal vein achieved through gentle pressure on the dilator, which breaks through the thin septum occluding the hepatic end of the vein.

topographic anatomy

The segmental anatomy of the liver has been reasonably well defined and is shown in Figure 1-1. In contrast to that of the lung, however, the segmental anatomy of the liver is relatively unimportant to the surgeon since the types of segmental resections that can be carried out so well in the lung are not possible in the liver because of the interlocking and traversing pattern of the inflow and outflow from the hepatic artery and portal vein and the outflow from the

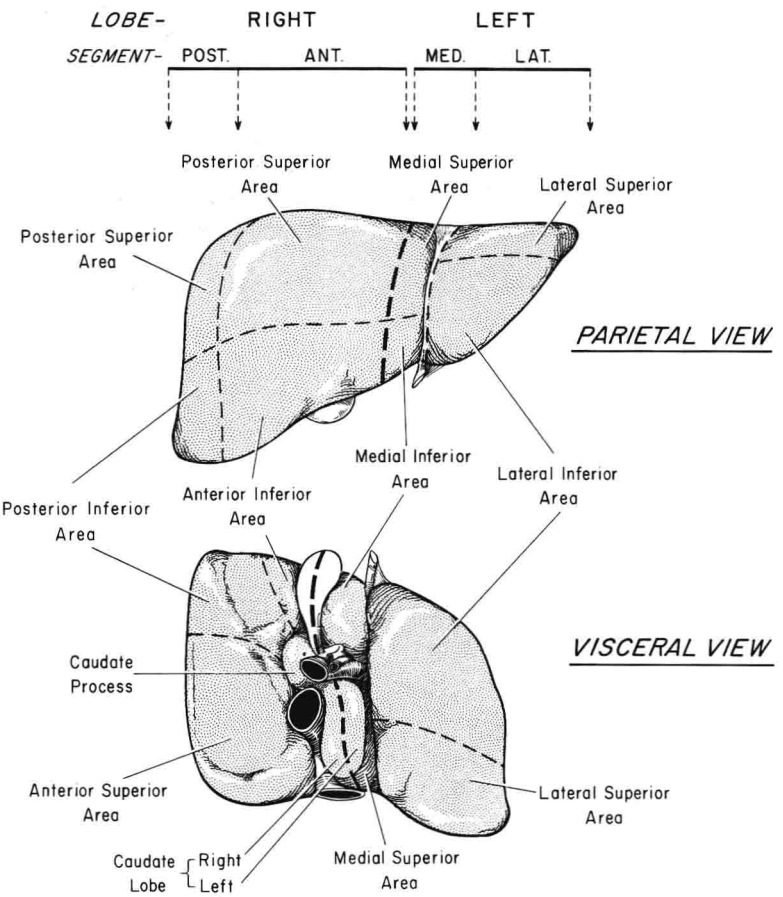

FIG. 1-1. Segmental anatomy of the liver

sinusoids and central and hepatic veins. In terms of surgical resection, one is usually limited to wedge resections, which are defined only as technical possibilities related to the thickness and configuration of the liver, and to major resections of the right and left lobes. In terms of specific localization of intrahepatic tumors, abscesses or cysts, and for more exact surgical descriptions, the segments as shown may be useful. The techniques of anatomic hepatic resection will be described in more detail, but in terms of gross anatomy and vascular supply, ligation of the right branches of the hepatic artery and portal vein will result in a line of demarcation between the major right and left lobes appearing 2 to 4 cm. lateral to the attachment of the round ligament and the reflection of the falciform ligament. If one dissects further along the left branch of the hepatic artery to its first bifurcation, one can often preserve the medial segment of the left lobe and carry out a resection of the lateral segment alone. Any more exact surgical resection by vascular segments is not, however, feasible.

the ligamentous attachments

The major ligamentous attachments and reflections of the liver can be identified in Figure 1-2. The *falciform ligament* is a peritoneal fold that extends from the umbilicus superiorly, contains the obliterated umbilical vein known as the round ligament and connects the liver to the anterior abdominal wall and the diaphragm.

On the posterior surface of the liver there is a bare area not covered by peritoneum but enclosed by an upper and lower layer of peritoneal reflections that contain the inferior vena cava and the hepatic veins. Surgical access to the posterior surface of the liver and these important vessels is obtained by dividing the lateral reflection and retracting the right lobe medially. The *hepatorenal ligament,* a reflection of the lower layer of the coronary ligament, passes to the upper pole of the right kidney, forming the lateral border of the

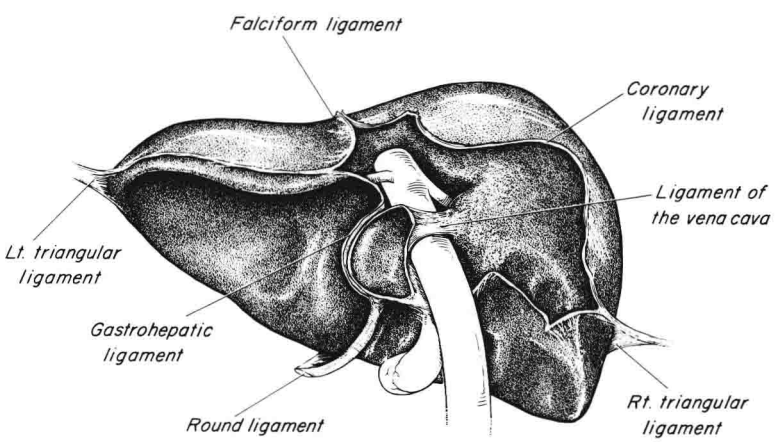

FIG. 1-2. The major ligamentous attachments of the liver

so-called hepatorenal fossa inferior and posterior to the gallbladder and gastrohepatic ligament. Division of this ligament is necessary for mobilization of the right lobe and must usually be done so that upward retraction of the right lobe will provide adequate access to the inferior vena cava during the dissection prior to the construction of a portacaval shunt. The *right triangular ligament* is the free margin of the coronary ligament. The *left triangular ligament* is continuous with the falciform ligament in front and the lesser omentum behind. These triangular ligaments form the attachments of the lobes of the liver to the under surface of the diaphragm.

lobular anatomy

A schematic cross-sectional drawing of the lobular pattern of the liver is shown in Figure 1-3. This illustrates the complex intercommunications of the vascular inflow through the hepatic artery and the portal veins with the sinusoids and thus with the central veins and the hepatic venules. The relationship of the bile ducts, their finite branches and the canaliculi can also be traced. These interdigitations are extremely complex. In addition to providing the mechanism by which the hepatic cell has access to nutrient material derived from the gut, they also identify the area where direct communication between the hepatic arterial inflow and the portal venules may occur, an arteriovenous communication that is of great importance to the

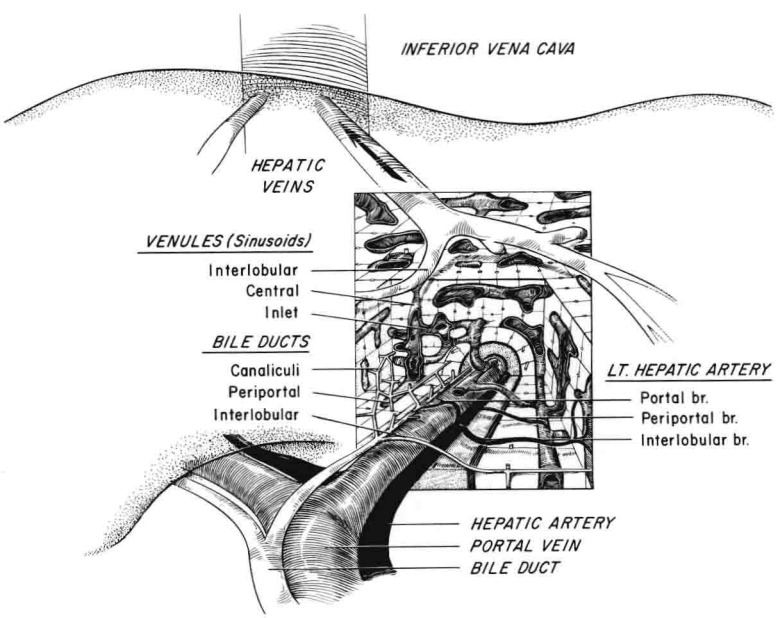

FIG. 1-3. Schematic representation of the lobular pattern of the liver

understanding of the hemodynamics of portal hypertension. Pressure and flow changes related to these communications will be discussed later under hemodynamics and the pathophysiology of portal hypertension.

vascular and biliary anatomy

Elaborate details of the blood supply of the liver and biliary tract are given in a beautiful series of descriptions and drawings by Michels; they will provide the surgeon who wishes to pursue not only the minute details of normal anatomy but the definitions of the innumerable anomalies that occur an opportunity for more information than is presented here. Only a rather cursory description of some of the more important anatomic details and more frequent anomalies will be given in this section.

portal circulation

The drawing in Figure 1-4 illustrates both the normal anatomy of the circulation with its major tributaries and the various routes of potential portal-systemic collateral channels that, in the presence of portal hypertension, provide egress of blood from the obstructed and congested splanchnic and splenic beds to the systemic venous circulation. In later sections concerned with surgical technique, reference will be made to those aspects of venous anatomy that are particu-

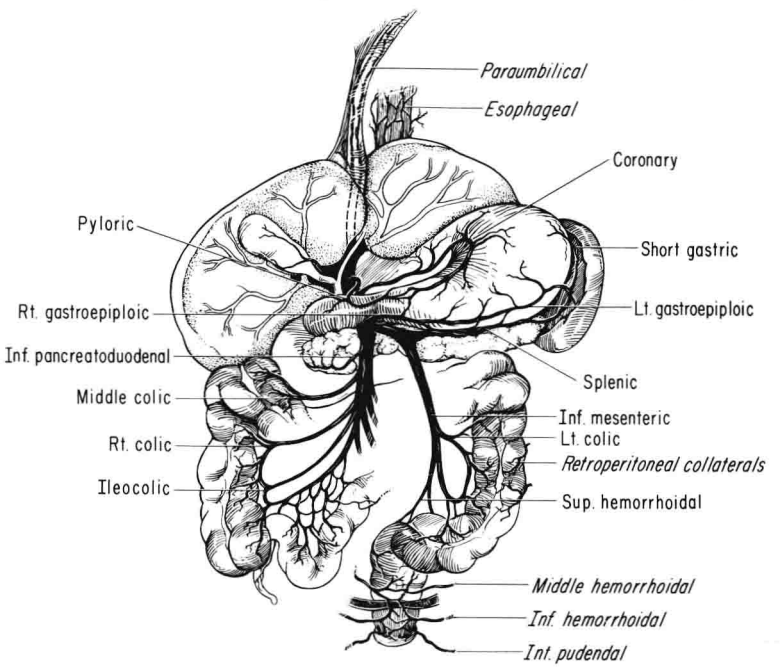

FIG. 1-4. Anatomy of the splanchnic circulation and portal-systemic collaterals

larly important and relevant to the completion of various types of surgical shunts.

hepatic arterial circulation

A precise knowledge of the hepatic arterial vascular patterns is of great importance to the surgeon operating on the liver and the upper abdominal organs, particularly the pancreas. The major variations are shown in Figures 1-5A to 1-5E; these are redrawn from Michels' descriptions based on a large series of dissections. They illustrate that what we usually consider the "normal" arterial pattern occurs in only 55 per cent of patients, and therefore one can anticipate the frequent occurrence of significant anomalies. Identification of the anatomic pattern of arterial supply to the liver is of extreme importance to

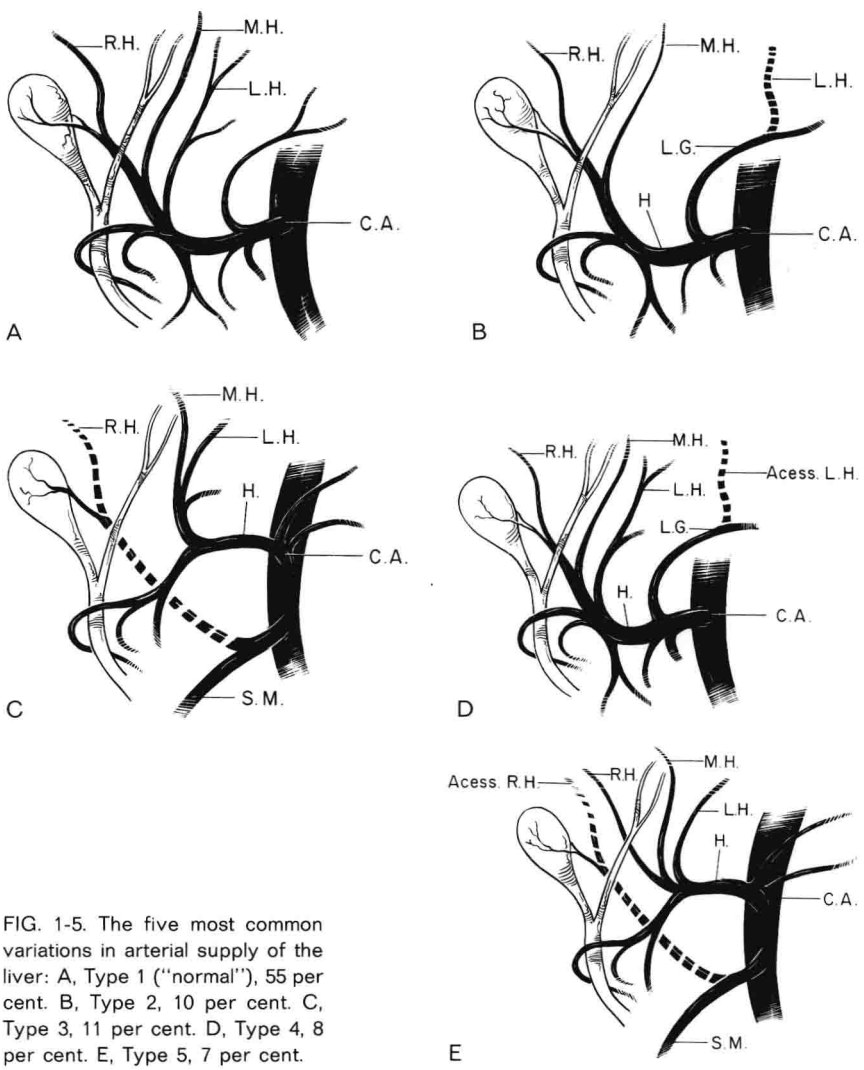

FIG. 1-5. The five most common variations in arterial supply of the liver: A, Type 1 ("normal"), 55 per cent. B, Type 2, 10 per cent. C, Type 3, 11 per cent. D, Type 4, 8 per cent. E, Type 5, 7 per cent.

the operating surgeon and is probably best defined with a selective hepatic arteriogram, a radiographic procedure that is an essential preliminary to any planned hepatic surgery. It is also vital if one is considering infusion chemotherapy, since the vascular anatomy will determine the placement of the catheter and will identify areas of the liver that may be perfused with any specific type of fluoroscopic placement. In carrying out hepatic resections it is important to identify the not infrequent occurrence of the type 3 and type 5 anomalies in which the right hepatic artery arises directly from the superior mesenteric vein. Since this anomalous origin occurs in almost one fifth of patients, it has been the cause of serious surgical problems encountered at operation. Not only in hepatic surgery but also in pancreaticoduodenectomy is it vital to recognize this particular pattern wherein the right hepatic artery passes behind the head of the pancreas and enters the liver by passing posteriorly in the gastrohepatic ligament.

hepatic veins

The venous outflow from the liver is extremely variable. There may be from three to eight small hepatic veins entering the vena cava posteriorly from the right, quadrate and caudate lobes. The main outflow from these areas of the hepatic parenchyma goes through the right hepatic vein, entering the vena cava posteriorly 2 to 4 cm. below the point where the cava passes through the diaphragm. The left hepatic veins and the blood from the left lobe usually enter the vena cava at the same level and medial to the right hepatic vein. Not infrequently, however, these two vessels become confluent within the substance of the liver and enter the vena cava posteriorly by a single trunk. It is of particular importance for the surgeon to recognize this anomaly when carrying out a right hepatic lobectomy; further reference to this anatomic feature will be made in a later chapter on the technique of hepatic resection.

the biliary system

Since this book is not directly concerned with surgery of the gallbladder, biliary tract and pancreas, no detailed reference to the normal and anomalous anatomy in these areas will be given. Certain specific references to details important to liver surgery will be made in the appropriate ensuing sections, and further reference to the superb text by Michels will provide extensive detail for any reader wishing to pursue this matter more extensively.

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Diagnostic Techniques in Liver Surgery

CHAPTER 2

There are a number of different special techniques that have been used in assessing the microscopic picture of liver disease and of evaluating the hemodynamic changes associated with disorders of the liver and portal circulation and certain special radiologic techniques that are of particular value. Table 2-1 indicates by outline those that seem particularly appropriate to refer to in this text.

percutaneous needle biopsy

A sample of liver tissue for microscopic study can be obtained safely and with minimal discomfort by percutaneous puncture of the liver with needles designed specifically for this purpose. The Vim-Silverman needle consists of a cannula and obturator used to perforate the skin and penetrate the liver parenchyma and an inner, forked obturator that replaces the original solid obturator when the needle has been positioned properly. This forked obturator is then introduced beyond the tip of the cannula, and by twisting, a sample of liver tissue may be withdrawn that has proved very satisfactory for purposes of diagnostic microscopic evaluation of the pathology. The Menghini method employs aspiration rather than cutting. When the instrument is positioned in the hepatic parenchyma, a syringe attachment is used to draw a sample into the needle for removal and later fixation and study. The safety of either technique depends on the appropriate selection of patients, and the techniques should not be utilized in any individual with any significant defect in the clotting mechanism. The patient must be cooperative and relaxed since both techniques require him to control his respiration at the appropriate point in the procedure. Since there is a slight but definite risk of continued bleeding after needle biopsy, it should not be carried out on an ambulatory

TABLE 2-1. Diagnostic Techniques in Liver Surgery

A. Percutaneous needle biopsy
B. Hemodynamic studies
   1. Hepatic blood flow
   2. Portal pressure measurements
      a. Splenic pulp pressures
      b. Hepatic wedge pressures
      c. Transumbilical or transhepatic portal pressures
C. Radiologic techniques
   1. Esophagography
   2. Angiography (arterial and venous)
   3. Scintiscanning

basis but only in hospitalized patients who can be observed for 24 hours subsequent to the procedure. In a relatively thin patient with a large, easily palpable liver, the subcostal route may be used, but ordinarily, a transthoracic, intercostal approach in the midaxillary line in the 9th interspace is the most satisfactory. During introduction of the needle and rapid removal of the sample, the patient must control his respiration and, as mentioned above, bed rest and monitoring of vital signs for a 24 hour period are essential.

hemodynamic studies

In a subsequent chapter on the hemodynamics of portal hypertension, reference will be made in more detail to measurements of hepatic blood flow and their significance. Briefly, the principles of measurement depend on the clearance by the reticuloendothelial system of the liver of an isotopically labeled colloid (usually either gold or chromic phosphate) or by continuous drip of Bromsulphalein (BSP), which is cleared by the hepatocytes and wherein determination of flow depends on utilization of the Fick principle with measurements peripherally and in the outflow tracts.

Portal pressure measurements will also be referred to in considerably more detail and their significance in the assessment of the hemodynamics of portal hypertension evaluated in a subsequent chapter. Percutaneous introduction of a needle into the spleen through the 9th interspace in the midaxillary line on the left will permit a direct measurement of pressure that correlates very well with recorded pressures in the portal vein at the time of operation. This can be done at the same time as splenoportography; it has been used by Rousselot in particular as a diagnostic technique in the emergency ward in patients with upper gastrointestinal bleeding. Relatively few