RADIOLOGY OF THE LIVER

McNULTY

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To
my Parents,
my First Teachers,
and
to Linda and Peter

FOREWORD

> "There are still among us benighted persons who would sympathize with the member of the House of Commons who, commenting on the extravagance of the London School Board, declared: 'Physiology, besides being costly and useless, is an immodest subject. When the Author of the Universe hid the liver of man out of sight He did not want frail human creatures to see how He had done it'." *Making Science Understandable* by Walter B. Cannon, 1871–1945

For many years the anatomic delineation of hepatic disease has been in the domain of the pathologist. Indeed, the liver had been "out of sight" until recently. The past 15 years, however, have seen the rise of radiologic detection of altered hepatic morphology and function. Radioisotopic liver scanning has provided for the delineation of regional hepatic function, but the resolution of anatomic detail has been left to diagnostic radiology.

Sophisticated techniques of arteriography, venography, cholangiography, and more recently, computed tomography have led to remarkable increases in our ability to discern hepatic pathology in vivo. James McNulty of the University of Dublin, was instrumental in the development of many of the techniques only now coming into use as we adopt a more sophisticated approach toward understanding of hepatic disease.

With this monograph, Dr. McNulty has provided us with the first comprehensive treatise on hepatic radiology in the English language. This book presents a systematic approach to the diagnosis and description of radiologic findings in liver disease, and clearly presents the relationships among vascular studies, cholangiographic studies, and alternative diagnostic modalities.

It is with great pleasure that we welcome the remarkable efforts of Dr. McNulty to the Saunders Monographs in Clinical Radiology. I am confident this book will become a benchmark for radiologists, surgeons, and gastroenterologists alike.

E. James Potchen, M.D.

PREFACE

Until recent years the liver was a most neglected organ in radiodiagnosis. Over the last decade new methods of diagnosis have considerably increased our knowledge of the liver and its diseases. In recent years new imaging techniques have demonstrated in an atraumatic manner many of the diseases formerly diagnosed only by sophisticated techniques.

This book has been designed to provide the information necessary for the intelligent use of the many radiological techniques available for the diagnosis of liver disease.

Chapter 1 reviews in detail the normal anatomy of the liver and biliary tract.

Chapter 2 provides a detailed survey of the various radiological methods available for "today's" diagnosis of diseases of the liver.

Chapters 3 to 8 contain descriptions of the radiological abnormalities encountered in liver disease. The text contains a comprehensive review of the radiological manifestations of liver disease and should prove useful to radiologists, gastroenterologists, internists and surgeons who have a special interest in the liver.

Much of the material will, of course, be familiar to the radiologist who regularly sees patients with liver disease. For the general radiologist, the text should provide a systematic source of reference.

The text contains most of the material required for the graduate examinations in radiology, hepatology, gastroenterology and other specialities that involve the liver and biliary tract.

It is hoped that the text will stimulate radiologists and others to become aware of and to take a greater interest in the diagnosis of diseases of the liver.

J. G. McNulty

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J. G. McNulty

CONTENTS

Chapter 1

NORMAL ANATOMY

GROSS ANATOMY OF THE LIVER

The liver, the largest glandular organ in the body, lies in the right upper abdomen inferior to the diaphragm. It occupies all of the right hypochondrium and most of the epigastrium, and often extends into the left hypochondrium as far as the left mammary line. A knowledge of the surface anatomy of the liver is essential for several diagnostic studies (Fig. 1–1). The adult liver weighs from 1.2 to 1.6 kilograms. Its consistency is that of a soft solid (Goss, 1966). The liver is highly vascular and is easily lacerated. It is irregularly hemispherical in shape, with a relatively smooth, convex diaphragmatic surface and a more irregular, concave visceral surface. The human liver has four anatomical lobes: a large right lobe, a smaller left lobe, and much smaller caudate and quadrate lobes. The diaphragmatic area of the liver has four surfaces: (1) anterior, (2) superior, (3) posterior, and (4) right.

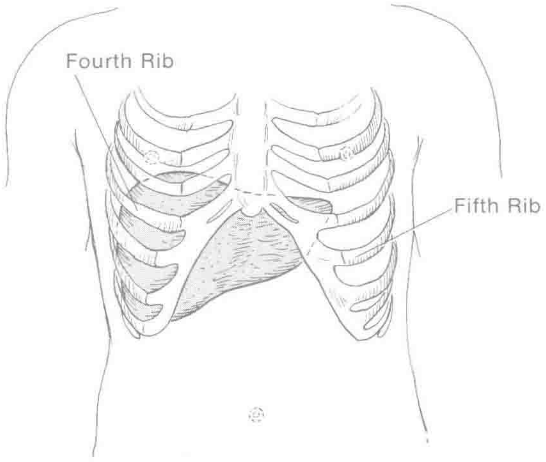


Figure 1–1. Normal surface markings of the liver in the anterior-posterior plane.

1. The anterior surface is separated by the diaphragm from the sixth to tenth ribs and their costal cartilages on the right side and from the seventh and eighth costal cartilages on the left. In the median region it lies posterior to the xyphoid process and that part of the muscular anterior abdominal wall between the diverging costal margins. It is completely covered by peritoneum except along the line of attachment of the falciform ligament.
2. The superior surface is separated by the domes of the diaphragm from the pleura and lungs on the right and by the pericardium and heart on the left. The area near the heart is marked by a shallow concavity, the cardiac fossa. This surface is mostly covered by peritoneum but along its dorsal part it is attached to the diaphragm by the superior reflection of the coronary ligament, which separates the part covered with peritoneum from the so-called bare area.

3 The posterior surface is broad and rounded on the right but narrow on the left. The central part presents a deep concavity, which is molded to fit against the vertebral column and crura of the diaphragm. Close to the right of this concavity the inferior vena cava lies almost buried in its fossa. Two or three centimeters to the left of the vena cava is the narrow fossa for the ductus venosus. The caudate lobe lies between these two fossae. To the right of the vena cava and partly on the visceral surface is a small, triangular, depressed area, the suprarenal impression for the right suprarenal gland. To the left of the fossa for the ductus venosus is the esophageal groove for the cardiac antrum of the esophagus. A large area of the dorsal part of the diaphragmatic surface is not covered by the peritoneum. It is attached to the diaphragm by loose connective tissue. The uncovered area, frequently called the bare area, is bounded by the superior and inferior reflections of the coronary ligament.

4. The right diaphragmatic surface of the liver merges with the other three diaphragmatic surfaces and continues down to the right margin, which separates it from the visceral surface.

The visceral surface is concave and faces posteriorly, inferiorly, and to the left. It contains several fossae and impressions for neighboring viscera. A prominent marking of the left central part is the porta hepatis, a fissure for the passage of the blood vessels and bile duct. The visceral surface is covered by peritoneum, except where the gallbladder is attached to it and at the porta. The right lobe, lying to the right of the gallbladder, has three impressions. On the right is the colic impression, a flattened or shallow area for the right colic flexure; more dorsally, a larger and deeper hollow is the renal impression for the right kidney; and the duodenal impression is a narrow and poorly marked area lying along the neck of the gallbladder.

Between the gallbladder and the fossa for the umbilical vein is the quadrate lobe, which is in relation with the pyloric end of the stomach, the superior portion of the duodenum, and the transverse colon. The left lobe, lying to the left of the umbilical vein fossa, has two prominent markings. A large hollow extending out to the margin is the gastric impression for the ventral surface of the stomach. Toward the right it merges into a rounded eminence, the tuber omentale, which fits into the lesser curvature of the stomach and lies over the ventral surface of the lesser omentum.

Just ventral to the inferior vena cava is a narrow strip of liver tissue, the caudate process, which connects the right inferior angle of the caudate lobe to the right lobe. Its peritoneal covering forms the ventral boundary of the epiploic foramen. The inferior border is thin and sharp, and is marked opposite the attachment of the falciform ligament by a deep notch, the umbilical notch, and opposite the cartilage of the ninth rib by a second notch, for the fundus of the gallbladder. In adult males this border generally corresponds with the lower margin of the thorax in the right mammary line but in women and children it usually projects below the ribs. In the erect position it often extends below the inter-iliac line. The left border of the liver is thin and flattened from above downward.

SEGMENTAL ANATOMY (Table 1–1)

As mentioned previously, the recognised anatomical lobes of the liver are the right and left lobes, separated by the falciform ligament, and the much smaller caudate and quadrate lobes. Physiological lobes, of much more importance to the surgeon and radiologist, are also recognised as right and left lobes separated by a physiological fissure that extends in an oblique sagittal plane from the gallbladder fossa posteriorly and to the groove of the inferior vena cava superiorly (Figs. 1–2 and 1–3). No surface markings indicate this physiological fissure. Vinyl acetate casts of the liver in which the hepatic veins are not injected demonstrate this "main boundary fissure" or "Hauptgrenzspalte" of Hjortsjo.

The physiological divisions of the liver follow the anatomical distribution of the hepatic arteries, bile ducts, and portal vein. The physiological fissure is occupied by the middle hepatic vein. No significant branches of bile ducts, hepatic arteries, or portal veins cross the main lobar fissure,

TABLE 1–1. The Segmental Anatomy of the Liver: A Comparison of Nomenclature

HEALEY AND SCHROY	COUINAUD	REIFFERSCHEID	HJORTSJO
Anterior–superior	VIII	Right paramediocranial	Ventrocranial
Anterior–inferior	V	Right paramediocaudal	Ventrocaudal
Posterior–superior	VII	Right lateral–cranial	Dorsocranial plus intermediocranial
Posterior–inferior	VI	Right lateral–caudal	Dorsocaudal plus intermediocaudal
Caudate lobe	I	Caudate lobe	Dorsal segment
Medial–superior	IV	Left paramediocranial	Central
Medial–inferior	IV	Left paramediocaudal (quadrate lobe)	Dorsoventral
Lateral–superior	II	Left laterocranial	Dorsolateral
Lateral–inferior	III	Left laterocaudal	Ventrolateral

hence it is a relatively safe plane for surgical resections of the liver. The physiological, or surgical, right and left lobes are each subdivided by fissures into two segments.

An oblique right segmental fissure divides the right lobe into an anterior and a posterior segment. It runs from a posterior superior position inferiorly and anteriorly to the hilum. A left segmental fissure divides the left lobe into a medial and a lateral segment. This left segmental fissure lies in the plane where the falciform ligament is attached to the parietal surface and is in line with the ligamentum venosum on the visceral surface. The medial segment of the left lobe corresponds to the quadrate lobe of the anatomist. Each segment has a superior and inferior area, with one specific major bile duct and artery for that area except the medial segment of the left lobe, which has double bile ducts and arteries for each superior and inferior area. The caudate lobe is divided into three parts, the caudate process and the right and left parts of the caudate lobe proper.

Usually three bile ducts drain the caudate lobe and two arteries supply it—one bile duct for each part, one artery for the caudate process and the right half of the caudate lobe proper and one artery for the left part of the caudate lobe.

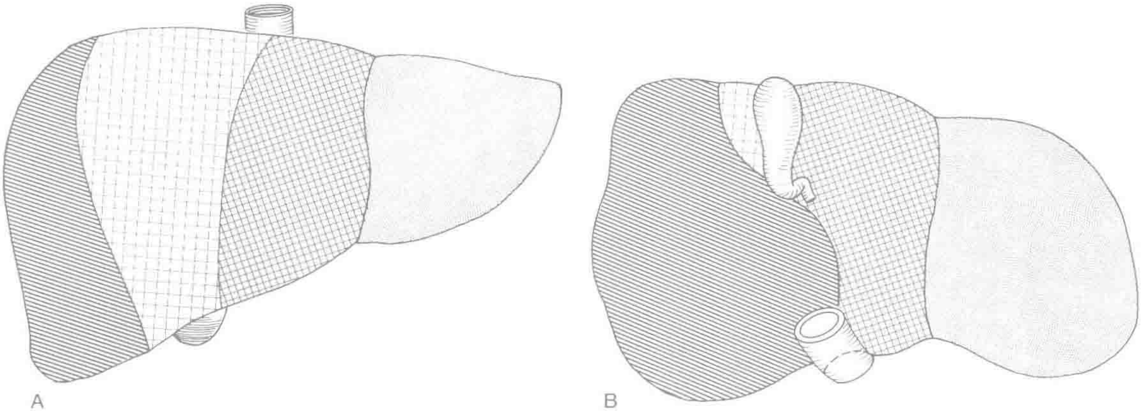


Figure 1–2. Segmental anatomy of the liver. *A*, Anterior view showing the anterior and posterior segments of the right lobe and the medial and lateral segments of the left lobe. *B*, Posterior view. The liver is shown as seen from below and behind the organ.

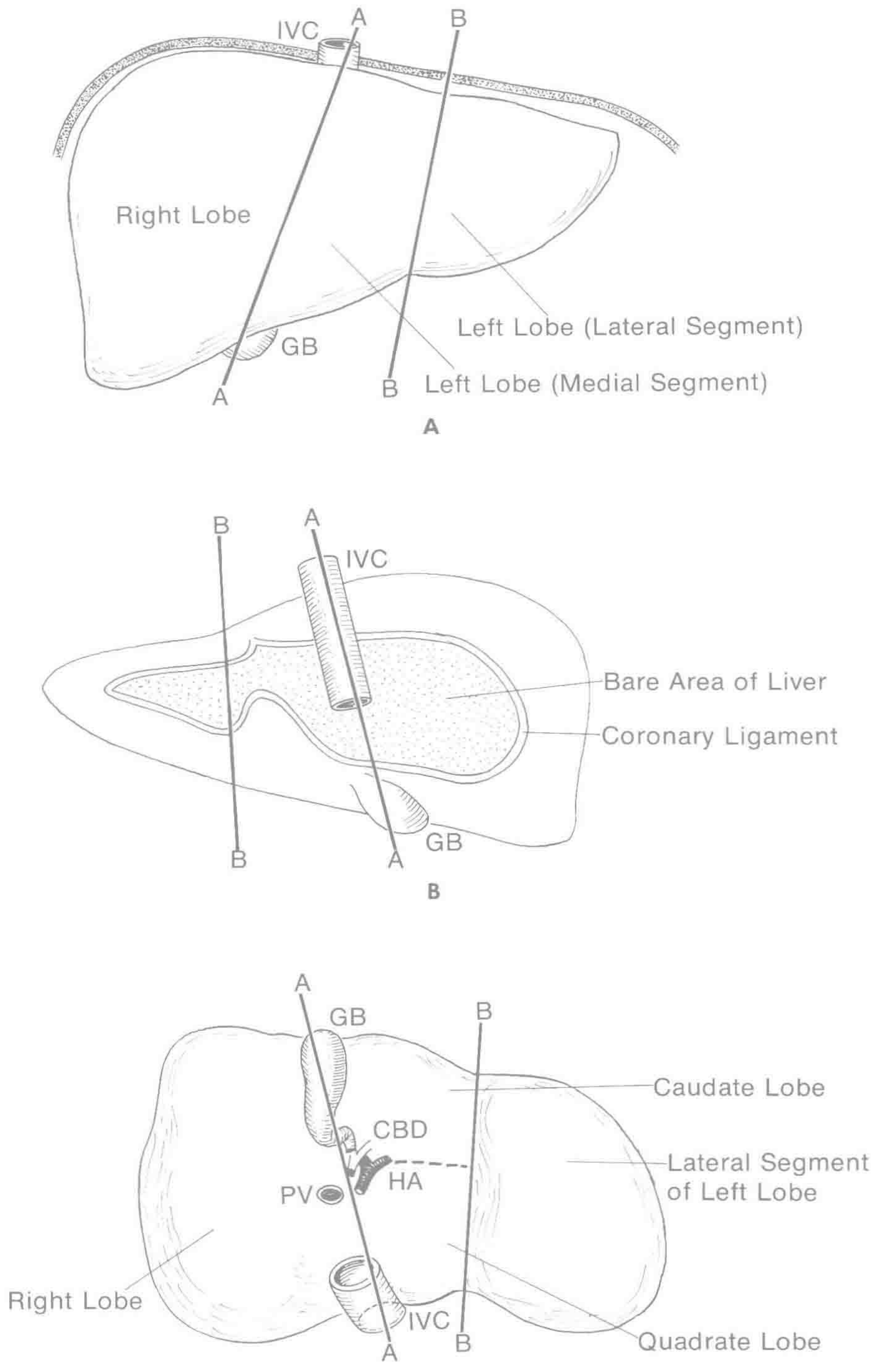
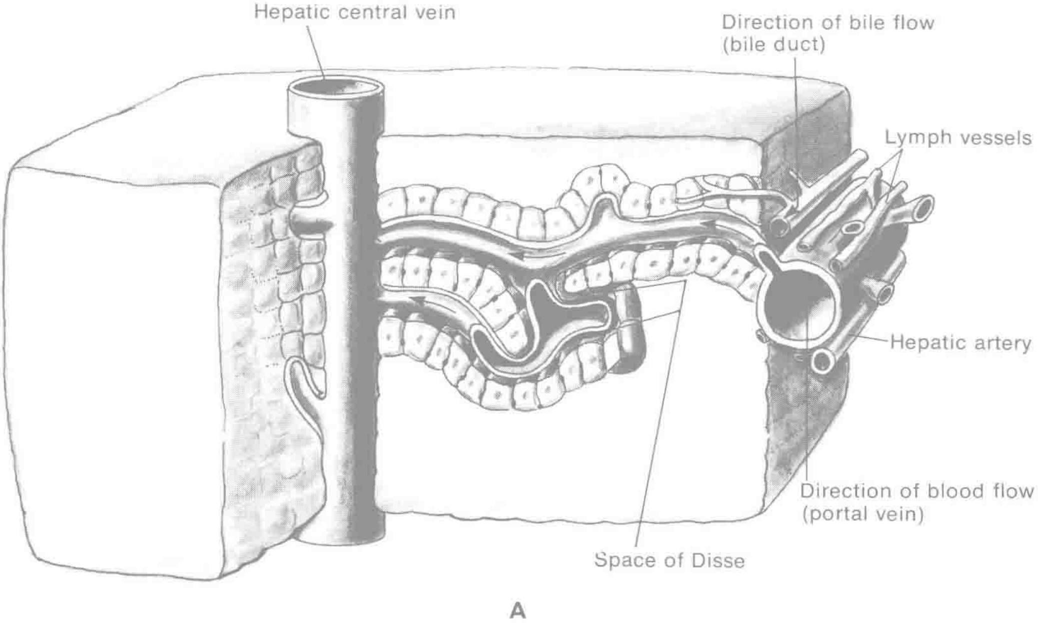


Figure 1–3. Gross anatomy of the liver. *A*, The lobar and segmental fissures, anterior view; *B*, the attachments of the coronary ligament enclosing the bare area on the posterior view; *C*, the position of the caudate and quadrate lobes, the porta hepatis, and the fissures on the inferior view. (A——A = lobar fissure; B——B = segmental fissure dividing the left lobe into medial and lateral segments. PV = portal vein; CBD = common bile duct; HA = hepatic artery; GB = gallbladder; IVC = inferior vena cava.

THE INTRAHEPATIC ARCHITECTURE
(Fig. 1–4)

The human liver consists of columns of cells radiating from a central vein and interlaced in an orderly fashion by sinusoids. Each hepatic lobule has at its periphery a portal tract composed of a radicle of a bile duct, an hepatic artery, and a portal vein. Columns of cells and liver sinusoids extend between the systems of hepatic veins and portal triads. The two systems run in



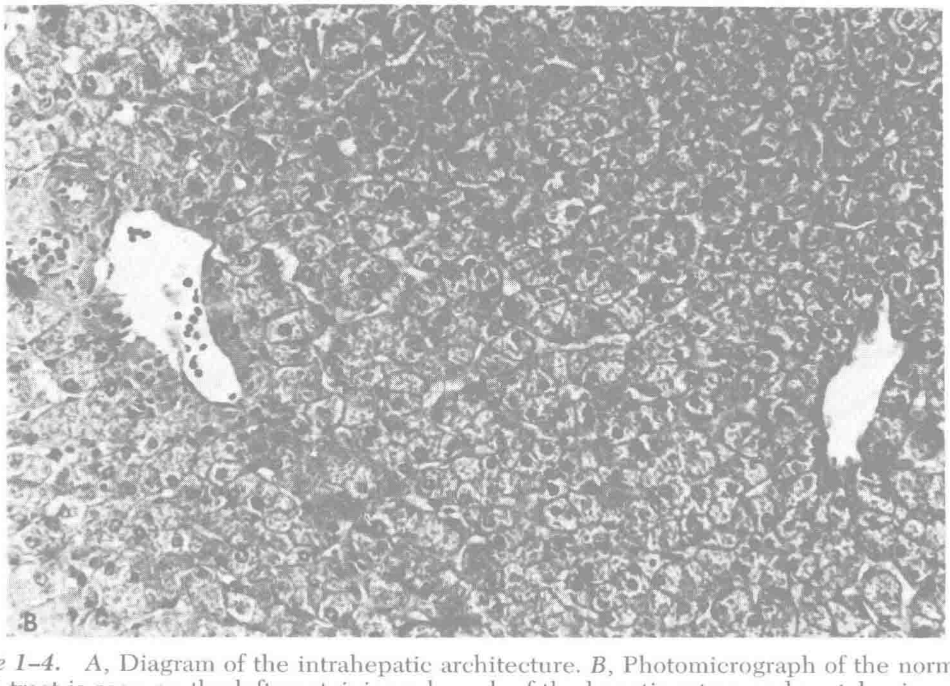


Figure 1–4. *A*, Diagram of the intrahepatic architecture. *B*, Photomicrograph of the normal liver: A portal tract is seen on the left containing a branch of the hepatic artery and portal vein and a bile duct. A hepatic vein is visible on the right. Normal liver cells lie between the hepatic vein centrally and the peripheral portal tract (Wedge biopsy, H&E × 100).

planes perpendicular to each other. The terminal portal radicles discharge the portal blood into the sinusoids, and the direction of flow toward the hepatic central vein is determined by the higher pressure in the portal system. The walls of the sinusoids consist of endothelial and phagocytic cells of the reticuloendothelial system.

Potential spaces between the hepatic cells and the sinusoid walls are visible at autopsy and are termed "the spaces of Disse." They contain tissue fluid which drains into lymphatics in the connective tissue of the peripheral areas. Hepatic arteries form a plexus around the bile ducts and supply the structures in the portal tracts. There are no direct hepatic arteriolar–portal vein anastomoses.

Bile canaliculi are minute tubules that lie on the surface of liver cells and form networks around the cells and drain into terminal bile ducts or cholangioles which drain into interlobular bile ducts in the portal tracts. The latter join with one another to form septal bile ducts, which eventually join to drain into the main hepatic ducts.

THE ANATOMY OF THE BILIARY TRACT

The bile ducts within the liver follow a segmental and lobar pattern. Anastomoses do not exist between the right and left lobes except in the porta hepatis. There is no communication between the bile ducts of the anterior and posterior segments of the right lobe.

In Healey's anatomical studies in 72 per cent of cases the right hepatic duct, averaging 9 mm in length, was formed by union of the anterior and posterior segmental ducts near the porta hepatis. In 28 per cent of cases either the anterior or posterior segmental duct crossed the lobar fissure to drain into the left hepatic duct. The lateral segment of the left lobe is drained by two segmental ducts, a small superior and a larger inferior duct, which unite at the line of the segmental fissure. The medial segment drainage is much more variable. In 60 per cent of cases all four of the area ducts joined to form a single medial segment duct. The lateral segment duct runs medially and inferiorly and joins the medial segment duct to form the left hepatic duct in the segmental fissure in 50 per cent of cases, or to the right of the fissure in 42 per cent of cases or to the left of the fissure in 8 per cent of cases (Healey and Schroy, 1953). The left hepatic duct has an average length of 1.7 cm. The caudate lobe drainage is variable; it may drain into both the right and left hepatic duct systems: the right half of the caudate lobe and the caudate process into the right hepatic duct and the left half of the caudate lobe into the left lobar duct system.

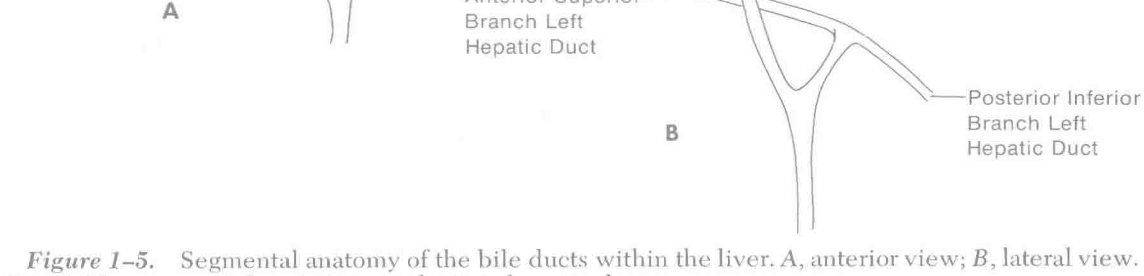


Figure 1–5. Segmental anatomy of the bile ducts within the liver. *A*, anterior view; *B*, lateral view. *C* to *J*, The congenital variations in the intrahepatic ducts.

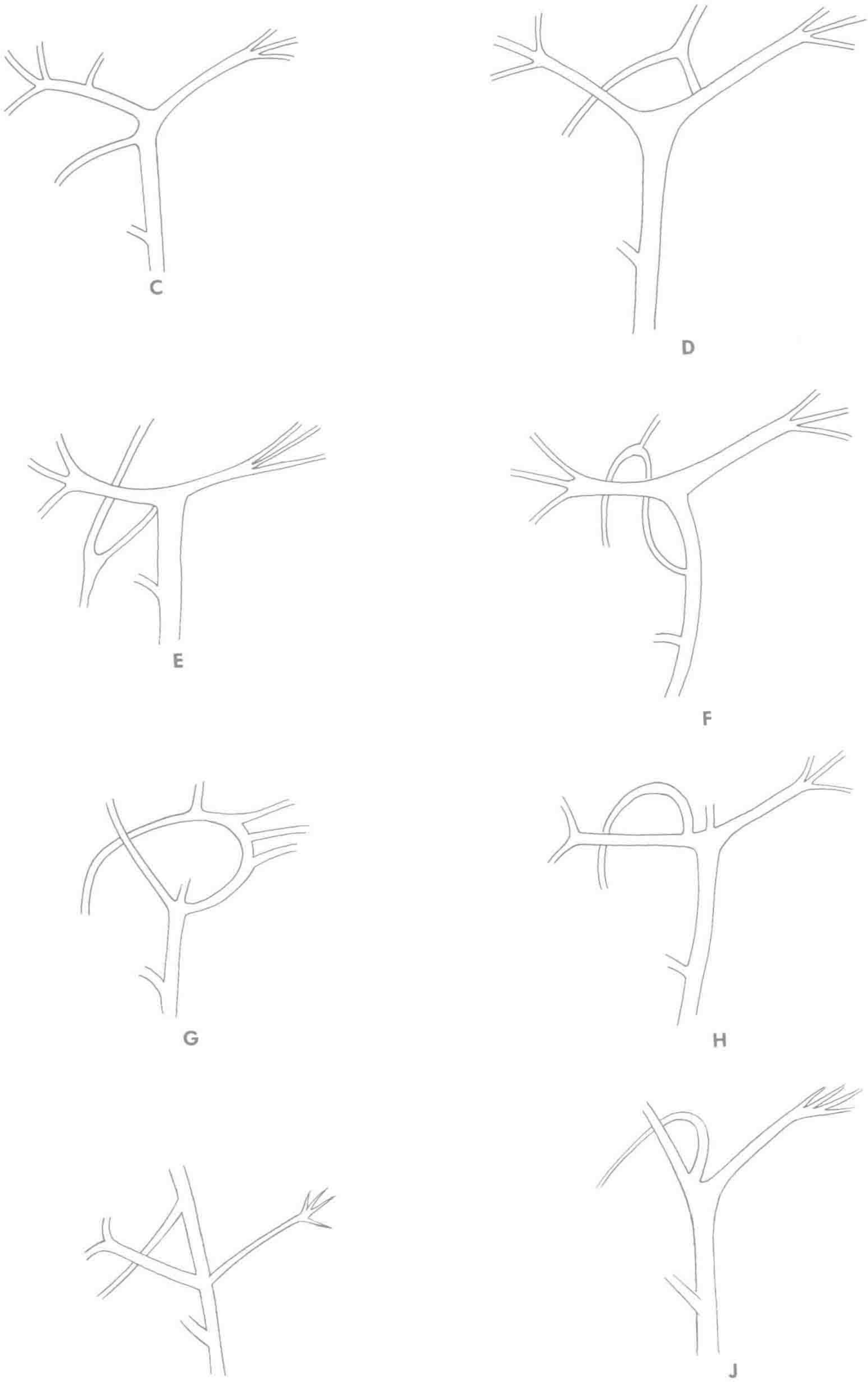


Figure 1–5 Continued.