CHAPTER 1
The Liver and Biliary Apparatus: Basic Structural Anatomy and Variations

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Introduction
The liver is one of the largest organs in the body, occupying at least 2–3% of the total adult body weight [1–3]. It weighs roughly 1200–1500 g in the average adult and, although not significant, reports have suggested that there may be population-specific variations in liver weight (1800–2600 g) [1].

Location and Surface Anatomy (Figure 1.1)
The liver appears wedge shaped, with its base to the right and its apex projecting to the left as it extends between the right and left upper quadrants. In its subdiaphragmatic position, the liver lies beneath the overlying ribs and cartilage. Its superior convex surface fills the concavity of the right dome of the diaphragm, reaching the fifth rib on the right and the fifth intercostal space, 7–8 cm from the midline, on the left. The upper margin may be traced at the level of the xiphisternal joint as it arches upward on each side. The right lateral margin therefore lies against the diaphragm and anterolateral thoracic wall, crossing the seventh to eleventh ribs along the midaxillary line. In comparison, the inferior border is sharp and may be followed just below the costal margin on the right extending to the left toward the fifth intercostal space. It is formed by a line joining the right lower and upper left extremities [2–11].

Peritoneal Relationships
As the liver continues to grow and enlarges during its development, the ventral mesentery is modified to form membranous folds that not only enclose almost the entire liver but also provide diaphragmatic and visceral...
attachments. At its upper pole, however, the liver makes
direct contact with the developing diaphragm and, as a
result, is devoid of peritoneum. This area is referred to
as the “bare area” and persists as the only portion of the
liver surface with no membranous covering.

Folds of peritoneum pass from the diaphragmatic and
visceral surfaces, connecting the liver to two main struc-
tures (Figure 1.2): (1) the diaphragm and (2) the stomach.
When entering the abdominal cavity during a dissection,
a sickle-shaped anterior fold of peritoneum is visible.

Figure 1.1 CT scans of liver in situ: (a) horizontal plane; (b) coronal plane. (c) Three-dimensional image of liver; (d) anterior view of liver in abdominal cavity. (Image (d) is courtesy of RF Morreale, 2008.)
This is known as the falciform ligament. It consists of two layers of adherent peritoneum and attaches the liver to the supraumbilical part of the anterior abdominal wall, as well as to the inferior surface of the thoracic diaphragm. Inferiorly, the falciform ligament is unattached and contains the ligamentum teres (obliterated left umbilical vein). As the falciform ligament ascends superiorly, it produces the left triangular ligament, which extends toward the left tip of the liver, but stops short, about two-thirds of the way along the superior margin, and is related to the lesser omentum along its posterior fold. As the falciform ligament passes superiorly and to the right, it gives rise to the upper layer of the coronary ligament, so named because it encircles the bare area of the liver. The inferior line of peritoneal attachment passes superiorly toward the summit of the liver, where it meets the leaf of the falciform ligament. These ligaments then attach to a groove, which lodges the ligamentum venosum (remnant of the ductus venosus). The coronary ligament fuses at its apex to form a small, rather insignificant right triangular ligament [2–11].

**Visceral Surface**

The visceral surface of the liver is best observed by superior rotation so that the inferior margin lies superiorly. Several key structures may be identified on this surface (Figure 1.3):

- **Porta hepatis:**
  - Two layers of lesser omentum deviate to the right and enclose the portal triad (portal vein, hepatic artery, bile duct)
  - Contains lymph nodes and nerves.
- **Gall-bladder fossa:**
  - Located on the inferior slope of the visceral surface with cystic duct close to the right margin of porta hepatis
  - Lies between the colic impression and the quadrate lobe.
- **Quadrate lobe:** between the gall-bladder fossa and fissure for ligamentum teres.
- **Bare area:** in contact with the diaphragm and right suprarenal gland.

In addition, the stomach, duodenum, hepatic flexure of the colon, and the right kidney form impressions on the visceral surface.

**Lobes**

Anatomically, the liver is divided into a larger right and a smaller left lobe using the line of attachment of the falciform ligament and fissures for ligamentum teres and ligamentum venosum. Functionally, the liver is divided along an oblique line that passes through the center of the bed of the gall bladder and the groove for the inferior vena cava (IVC) along the plane of the middle hepatic vein [12,13].
The quadrate lobe is located on the superior part of the visceral surface, bound by the fissure for ligamentum teres on the left and the gall-bladder fossa on the right. Anatomically, it is considered part of the right lobe but remains, functionally, part of the left lobe.

The caudate lobe is located on the inferior part of the visceral surface of the liver, bound by the fissure for ligamentum venosum on the left and by the groove for the IVC on the right. The caudate lobe exhibits a complex anatomy and is said to be embryologically and anatomically independent of the right and left lobes of the liver [14,15]. It therefore remains a separate anatomic segment. The right portion of the caudate lobe extends as the caudate process which forms the superior boundary of the epiploic foramen. Description of the functional segments of the liver has been based on blood supply (systemic and portal) and venous and biliary drainage. Although there are several descriptions of segmental anatomy, the most commonly applied nomenclature is based on Bismuth's interpretation [16], where all hepatic segments, except for the caudate lobe, are defined by three vertical fissures and a single transverse fissure. Of these fissures, only one appears to be represented superficially (portoumbilical fissure) [12,13], while the others are related to three large hepatic veins. The right fissure, lying almost in the coronal plane, contains the right hepatic vein. The median fissure passes from the gall-bladder fossa to the left margin of the IVC. The left
fissure runs from the left side of the IVC toward the left margin of the liver (a point between the dorsal third and ventral two-thirds), passing inferiorly to the start of the ligamentum venosum. The portoumbilical fissure is marked by the attachment of the falciform ligament [12].

The simplest way to understand the segmental anatomy of the liver is to view it in four sectors (a left medial and left lateral sector and a right anterior and right posterior sector) which are then divided into eight segments [12,13]. The left lateral sector lies to the left of the falciform ligament attachment and the grooves for ligamentum teres and ligamentum venosum, with the left medial sector lying between these lines and the plane of the gall bladder and the IVC. There is no external marking between the right anterior and posterior sectors. The plane runs obliquely, posteriorly and medially from the middle of the front of the right lobe toward the groove for the IVC. The segments may be identified as follows (Figure 1.4):

- Segment I: caudate lobe
- Segments II and III: left hepatic vein passes between segments
- Segments IVa and IVb: quadrate lobe
- Segments V and VI: inferior segments of right anterior and right posterior sectors
- Segments VII and VIII: superior segments of right anterior and right posterior sectors.

The following are basic points on hepatic nomenclature [2,12,13,16]:

- All hepatic segments except for the caudate lobe are defined by three vertical divisions and a single transverse division.
- The middle hepatic vein divides the liver into right and left hemi-livers.
- The right hemi-liver is divided by the right hepatic vein into anterior and posterior segments.
- The left hemi-liver is divided by the left hepatic vein into medial and lateral segments.
- Four segments are divided by a transverse line that passes through the right and left portal branches.
- In a frontal view, eight segments are numbered clockwise.

**Microscopic Organization**

Structurally, the liver is composed of the following:

- **Parenchyma:**
  - organized plates of hepatocytes
  - normally one cell thick (in adults, two cell layers in children aged 6 years).
- **Connective tissue stroma:**
  - contains blood vessels, nerves, lymphatic vessels, and bile ducts
  - continuous with the fibrous capsule of Glisson, covering the surface of the liver.
• Sinusoidal capillaries (sinusoids): vascular channels located between the plates of hepatocytes.
• Perisinusoidal spaces (spaces of Disse): located between the sinusoidal endothelium and hepatocytes.

The best approach to understanding the organization of the liver parenchyma is by visualizing a classic lobule. The architecture of this lobule is based on the distribution of the branches of the portal vein and hepatic artery within the liver and by the flow of blood when perfusing the liver [17–19].

**Classic Liver Lobule**

The liver lobule is roughly hexagonal, measures about 2.0 \( \times \) 0.7 mm and consists of stacks of anastomosing plates of hepatocytes, one cell layer thick, separated by the anastomosing system of sinusoids that perfuse the cells with the mixed portal and arterial blood (Figure 1.5). At the center of the lobule is the terminal hepatic venule (central vein), into which the sinusoids drain. From the central vein, plates of cells radiate to the periphery of the lobule, as do sinusoids. Portal canals are located at the angles of the hexagon and bordered by the outermost hepatocytes of the lobule—loose stromal connective tissue (continuous with the fibrous capsule of the liver) characterized by the presence of the portal triads. Between the connective tissue stroma and the hepatocytes at the edges of the portal canal, a small space referred to as the space of Mall can be found. This space is thought to be one of the sites where lymph originates in the liver [17–19].

**Hepatocytes**

Hepatocytes are large, polygonal cells measuring between 20 and 30 μm and constitute about 80% of the cell population of the liver.

**Polygonal Structure.** Two of its surfaces face the perisinusoidal space. The plasma membrane of the two surfaces faces a neighboring hepatocyte and a bile canaliculus. Assuming that the cell is cuboidal, the remaining two surfaces would also face neighboring cells and bile canaliculi. The surfaces that face the perisinusoidal space correspond to the basal surface of other epithelial cells and those that face neighboring cells and bile canaliculi correspond to the lateral and apical surfaces, respectively, of other epithelial cells [17–19].

**Hepatocyte Nuclei.** Nuclei are large, spherical, and located in the center of the cell. In the adult liver, many cells are binucleate; two or more well-developed nucleoli are present in each nucleus. Cytoplasm is generally acidophilic [17–19].

**Hepatocyte Organelles.** The following organelles are visible through specific staining techniques [17–19]:
• Extensive smooth endoplasmic reticulum (sER) with varying metabolic activity. Under conditions of hepatocyte challenge by drugs, toxins, or metabolic stimulants, the sER may become the predominant organelle in the cell.
• Presence of mitochondria: as many as 800–1000 per cell.
• Large numbers of peroxisomes (200–300).
• Large Golgi apparatus consisting of as many as 50 Golgi units, each of which consists of three to five closely stacked cisternae, plus many large and small vesicles. Elements of the Golgi apparatus concentrated near the bile canaliculus are believed to be associated with the exocrine secretion of bile.
• Heterogeneous population of lysosomes concentrated near the bile canaliculus.
• Deposits of glycogen (in a well-preserved hematoxylin and eosin (H & E) preparation; glycogen is also visible as irregular spaces, usually giving a fine foamy appearance to the cytoplasm).
• Lipid droplets of varying sizes. The number of lipid droplets increases after injection or ingestion of certain hepatotoxins, including ethanol.
• Various amounts of lipofuscin pigment within lysosomes.

![Figure 1.5](image-url) Organization of liver lobules (low magnification), ×85. Arrowheads indicate the central vein.
Blood Supply

The liver receives about 70% of its blood via the portal vein and 30% from the hepatic artery [2–5]. The hepatic artery commonly arises from the celiac trunk but may sometimes come off the superior mesenteric artery or as a separate branch of the aorta. It divides into right and left branches. The right branch passes behind the common hepatic duct and divides into anterior and posterior branches within the liver. The left branch divides into medial and lateral branches within the liver. Occasionally, these branches may arise from the superior mesenteric artery (15%) or the left gastric artery (20%) and may be additional or replace the normal branches [2,3]. There is no communication between the right and left halves of the liver. The arteries are said to be “end-arteries” [2,12]. Figure 1.6 shows the arterial pattern and Figure 1.7 shows the liver vascular tree.

**Figure 1.6** (a) Liver arterial pattern; (b) liver venous pattern. (Courtesy of RF Morreale, 2008.)
The portal vein is formed by the union of the superior mesenteric and splenic veins behind the neck of the pancreas. It measures roughly 7–10 cm in length and has a diameter of 0.8–1.4 cm [2,3]. The portal vein has no valves. At the porta hepatis, the portal vein divides into right and left branches before it enters the liver. The right branch of portal vein is shorter than the left. It lies anterior to the caudate process, follows the distribution of the right hepatic artery and duct, and bifurcates into 17 anterior and posterior segmental branches, with further divisions into subsegmental parenchymal branches. The left branch of the portal vein is longer and has transverse and umbilical parts. It starts as the transverse part in the porta hepatis which, on its way to the left, gives off a caudate branch. After turning sharply at the level of the umbilical fissure, the umbilical part continues anteriorly in the direction of the round ligament to terminate in a blind end proximal to the inferior border of the liver, where it is joined by the round ligament [2–7,9,10].

Venous and Lymphatic Drainage
The venous drainage shows mixing of blood between the right and left halves of the liver. There are three main hepatic veins that drain into the IVC. A large central vein runs in between the right and left halves and receives blood from each. A right and left vein lie further laterally and, frequently, a middle hepatic vein joins the left vein close to the IVC. These veins have no extrahepatic course and drain into the IVC just below the central tendon of the diaphragm. In addition, there are several small hepatic veins that enter the IVC below the main veins, as well as a separate vein draining the caudate lobe. Anastomoses between the portal channels and the azygos system of veins have been observed in the bare area of the liver [2–5,11,12].

The lymphatic drainage may be summarized as follows [2]:

- Drainage into three to four nodes that lie in porta hepatis
- Drainage into pyloric nodes and celiac nodes
- Receives lymphatics from the gall bladder
- Communication with extraperitoneal lymphatics from bare area—perforate the diaphragm and drain into nodes of the posterior mediastinum; similar communications from the left triangular and falciform ligaments.

Interlobular Vessels
Interlobular vessels occupy the portal canals with only those that form the smallest portal triads sending blood into the sinusoids (Figure 1.8). Larger interlobular vessels branch into distributing vessels located at the periphery of the lobule. These distributing vessels send inlet vessels to the sinusoids. In the sinusoids, the blood flows centripetally toward the central vein. As the central vein courses through the central axis of the classic liver lobule, it becomes larger and eventually empties into a sublobular vein. Convergence of several sublobular veins forms larger hepatic veins which empty into the IVC [17–19].
Structurally, the portal vein and the hepatic artery, with their tributaries and branches, are typical of veins and arteries in general. In addition to providing arterial blood directly to the sinusoids, the hepatic artery provides arterial blood to the connective tissue and other structures in the larger portal canals. Capillaries in these larger portal canals return the blood to the interlobular veins before they empty into the sinusoid [17–19].

The thin-walled central vein receives blood from the hepatic sinusoids. Its endothelial lining is surrounded by small amounts of spirally arranged connective tissue fibers. The sublobular vein, the vessel that receives blood from the terminal hepatic venules, has a distinct layer of connective tissue fibers (both collagenous and elastic) just external to the endothelium. The sublobular veins and the hepatic veins, into which they drain, travel alone. As a result of their solitary nature, they can be readily distinguished in a histologic section from the portal veins that are members of a triad. Hepatic veins have no valves [17–19].

Hepatic sinusoids are lined by a thin discontinuous endothelium with underlying discontinuous basal lamina that is absent over large areas. As opposed to other sinusoids, hepatic sinusoids contain a phagocytic cell derived from monocytes referred to as a Kupffer cell in the vessel lining. Kupffer cells do not form junctions with neighboring endothelial cells but processes of Kupffer cells often seem to span the sinusoidal lumen and may even partially occlude it [17].

The perisinusoidal space (space of Disse) is the site of exchange of materials between blood and liver cells (Figure 1.9). It lies between the basal surfaces of hepatocytes and the basal surfaces of endothelial cells and Kupffer cells that line the sinusoids. Small, irregular microvilli project into this space from the basal surface of the hepatocytes. As a result of the large gaps in the endothelial layer and the absence of a continuous basal lamina, there is no significant barrier between the blood plasma in the sinusoid and the hepatocyte plasma membrane. Proteins and lipoproteins synthesized by the hepatocyte are transferred into the blood in the perisinusoidal.
space; this pathway is for liver secretions other than bile [17–19].

**Lymphatic Pathway**

Plasma that remains in the perisinusoidal space drains into the periportal connective tissue where a small space, the space of Mall, is described between the stroma of the portal canal and the outermost hepatocytes. Lymphatic fluid then enters lymphatic capillaries which travel with the other components of the portal triad [17].

Lymph in progressively larger vessels follows the same direction as the bile (i.e., from the level of the hepatocytes toward the portal canals and eventually to the hilum of the liver). About 80% of the hepatic lymph follows this pathway and drains into the thoracic duct [17] (Figure 1.10).

**Innervation**

Sympathetic fibers from the celiac ganglion give off nerves that run with vessels in the free edge of the lesser omentum and enter the porta hepatis. Parasympathetic fibers arise from the hepatic branch of the anterior vagal trunk and reach porta hepatis via lesser omentum [2,3].

**The Biliary Apparatus**

The biliary apparatus consists of three hepatic ducts (right, left, and common), gall bladder and cystic duct, and the bile duct. In terms of their relationship, the right and left hepatic ducts go on to form the common hepatic duct to the right side of the porta hepatis. The common hepatic duct is joined on the right side by the cystic duct, which enters at an acute angle to form the bile duct [2–6] (Figure 1.11).
The common bile duct is about 6–8 cm long and its normal diameter does not exceed 8 mm. For descriptive purposes, the bile duct may be divided into three parts [2,3]:

1. **Supraduodenal**: lies in the free edge of the lesser omentum in front of the portal vein and to the right of the hepatic artery.
2. **Retroduodenal**:
   - lies behind the first part of the duodenum, slopes down and to the right
   - portal vein lies to the left of the duct with the gastroduodenal artery
   - the IVC lies behind the duct.
3. **Paraduodenal**: slopes further to the right in a groove between the posterior surface of the head of the pancreas and the second part of the duodenum, and in front of the right renal vein.
   Joins the pancreatic duct at a 60° angle at the hepatopancreatic ampulla.

**Innervation**
Parasympathetic fibers run from the anterior vagal trunk and sympathetic from the celiac ganglion [2,3].

**Microscopic Anatomy**
The biliary system is formed from channels of increasing diameter, through which bile flows from the hepatocytes to the gall bladder and then to the intestines. These structures are not only passive conduits, but also capable of modifying bile flow and changing its composition in response to hormonal and neural stimulation.

Cholangiocytes (epithelial cells), which monitor bile flow and regulate its content, line the biliary system. These cells are identified by their organelle-scant cytoplasm, presence of tight junctions, and complete basal lamina. An apical domain of cholangiocytes appears similar to hepatocytes, with microvilli projecting into the lumen. In addition, each cholangiocyte contains primary cilia that sense changes in luminal flow, resulting in alterations of cholangiocyte secretion [17–19].

Bile flows from the region of the terminal hepatic venule (central vein) toward the portal canal (a direction opposite to the blood flow) (centrifugal flow). The smallest branches of the biliary system are the bile canaliculi, into which the hepatocytes secrete bile. They form a complete loop around four sides of the idealized six-sided hepatocytes. They are approximately 0.5 μm in luminal diameter and are isolated from the rest of the intercellular compartment by tight junctions (part of junctional complexes). Microvilli of the two adjacent hepatocytes extend into the canalicular lumen. Near the portal canal, bile canaliculi join together to form a larger channel, known as the canal of Hering. Its lining is made of two types of cells, hepatocytes and cholangiocytes. The main distinction between the canal of Hering and the bile ductule is whether the structure is partially or completely lined by cholangiocytes. Bile ductules carry bile to the interlobular bile ducts. These ducts range from 15 μm to 40 μm in diameter and are lined by cholangiocytes, which are cuboidal near the lobules and gradually become columnar as the ducts near the porta hepatis. As the bile ducts get larger, they gradually acquire a dense connective tissue investment containing numerous elastic fibers. Smooth muscle cells appear in this connective tissue as the ducts approach the hilum. Interlobular ducts unite to form right and left hepatic ducts and, together, the common hepatic duct. The common hepatic duct is lined with tall columnar epithelial cells and possesses all the same layers of the alimentary canal, except the muscularis mucosae [17–19] (Figure 1.12).

**The Gall Bladder**

**Gross Anatomy**
The gall bladder is a pear-shaped organ that consists of a fundus, body, and neck. As already described, it lies in the fossa for the gall bladder on the visceral surface of the liver, adjacent to the quadrate lobe. The gall bladder is covered by the peritoneum over the liver, although some-
times it may hang free on a narrow mesentery and, only rarely, be embedded. It varies in size and shape, may be duplicated, with single or double cystic ducts, and very rarely absent. The fundus usually projects below the margin of the liver and may be located at the tip of the ninth costal cartilage where the transpyloric plane crosses the right costal margin. Internally, it is related to the left of the hepatic flexure of the transverse colon. The fundus is not normally palpable, except in disease. The body passes towards the right of the porta hepatis and is related to the first part of the duodenum. As the body narrows, it forms the neck which, with further narrowing, produces the cystic duct that passes backward and inferiorly to join the common hepatic duct in front of the right hepatic artery and its cystic branch [2,3,5–7].

The gall bladder receives its blood supply from the cystic artery (commonly a branch of the right hepatic artery, but may arise from gastroduodenal artery or main trunk of the hepatic artery) and its venous drainage is via numerous cystic veins. The cystic artery may be located in the Calot triangle which also contains the cystic lymph node.

Microscopic Anatomy

The empty or partially filled gallbladder has numerous deep mucosal folds. Deep diverticula of the mucosa, called Rokitansky–Aschoff sinuses, are sometimes present and extend through muscularis externa. The mucosal surface consists of simple columnar epithelium. Tall epithelial cells exhibit numerous, but not well-developed, apical microvilli, well-developed junctional complexes, numerous mitochondria in the apical and basal cytoplasm, and complex plications on the lateral basal membrane. The lamina propria is also very cellular, containing large numbers of lymphocytes and plasma cells. It is particularly rich in fenestrated capillaries and small venules, but there are no lymphatic vessels in this layer. Mucin-secreting glands are sometimes present in the lamina propria, especially near the neck of the organ. Cells that appear identical to enteroendocrine cells of the intestine are also found in these glands. External to the lamina propria is muscularis externa with numerous collagen and elastic fibers, among somewhat randomly oriented bundles of smooth muscle cells. Despite its origin from a foregut-derived tube, the gall bladder does not have muscularis mucosae or submucosa. External to muscularis externa is a thick layer of dense connective tissue containing large blood vessels, extensive lymphatic network, and autonomic nerves. The connective tissue is also rich in elastic fibers and adipose tissue. The layer of tissue where the gall bladder attaches to the liver surface is referred to as the adventitia. The unattached surface is covered by a serosa or visceral peritoneum consisting of a layer of mesothelium and a thin layer of loose connective tissue [17–19].

Developmental Anatomy and Variations of the Liver

At the start of the fourth week of intrauterine life, the liver is one of the first organs to develop, undergoing rapid growth to fill the abdominal cavity and amounting to 10% of the total fetal weight by the ninth week of development [20–23].

The liver, biliary system, and gall bladder are said to arise as a ventral outgrowth from the caudal part of the foregut. This ventral outgrowth is described as being “Y” shaped and known as the hepatic diverticulum. At the same time, a thick mass of splanchnic mesoderm, the septum transversum, develops on the cranial aspect of the coelomic cavity (between the developing heart and the midgut). The cranial part of the septum transversum gives rise to the pericardial cavity (and, eventually, pericardium) and the diaphragm. The caudal part is, however, soon invaded by the developing liver and, as the liver
grows, it is said to become surrounded by the septum transversum, which is then referred to as the ventral mesogastrium [20,21]. As the liver grows into the ventral mesogastrium, it divides into two parts. The larger, more cranial part is the primordium of the liver. The smaller, more caudal part gives rise to the gall bladder. The stalk of the hepatic diverticulum goes on to form the cystic duct and the stalk connecting the hepatic and cystic ducts to the duodenum forms the bile duct. It is important to note that, initially, the bile duct is attached to the ventral aspect of the duodenal loop. However, rotation of the duodenum carries the bile duct to its dorsal aspect, where it maintains its position throughout adult life [2,3,20–23].

As the endodermal cells now proliferate, they appear to give rise to intermingling cords of hepatocytes as well as the epithelial lining of the intrahepatic part of the biliary apparatus. These hepatic cords then anastomose around the early endothelial lined hepatic sinusoids [20–23].

The fibrous and hemopoietic tissue, as well as the Kupffer cells, are said to be derivatives of the mesenchyme of the septum transversum. Hemopoiesis usually begins at around week 6 and bile formation, around week 12 of development [3,20,21].

As liver development is not subject to frequent deviation, variations in liver anatomy are rare. However, cases have been recorded and are summarized below [24]:

- The liver may have no lobar division.
- Accessory lobes may be present or division of the liver into 12 lobes may be possible.
- A detached portion forming a short accessory appendage on the left lobe may be observed. In this case, the appendage is usually covered by a fold of peritoneum containing blood vessels.
- The presence of two additional lobes has been reported: (a) lobus posterior—projecting through the epiploic foramen (lying behind the stomach); and (b) lobus vena cava—projecting along the course of the IVC.
- The left triangular ligament may contain liver tissue.
- A bridge of liver segment of varying size may connect the quadrate and left lobes.
- A smaller accessory liver may be found adherent to the pancreas.
- Isolated masses of liver have been observed on the wall of the gall bladder, ligamentum teres, spleen, and greater omentum.

Reports highlighting variations of liver and biliary anatomy and its importance in clinical procedures continue to add to the banks of existing knowledge [25–27].

### Take-home points

The liver:
- develops from a ventral outgrowth known as the hepatic diverticulum and grows into the ventral mesogastrium
- extends between right and left upper quadrants in a subdiaphragmatic position reaching as high as the fifth rib and as low as the eleventh rib on the right
- is related to the peritoneum by the falciform, coronary, and triangular ligaments, and connected to ligamentum teres and ligamentum venosum
- receives its blood supply from the hepatic artery (30%) and the portal vein (70%)
- consists of anatomic lobes and functional segments
- is connected to the biliary apparatus, which consists of the gall bladder, and hepatic, cystic, and bile ducts
- exhibits microscopic organization of hexagonally shaped lobules with a central vein
- may have developmental anomalies and variations present but these are rare.

### References