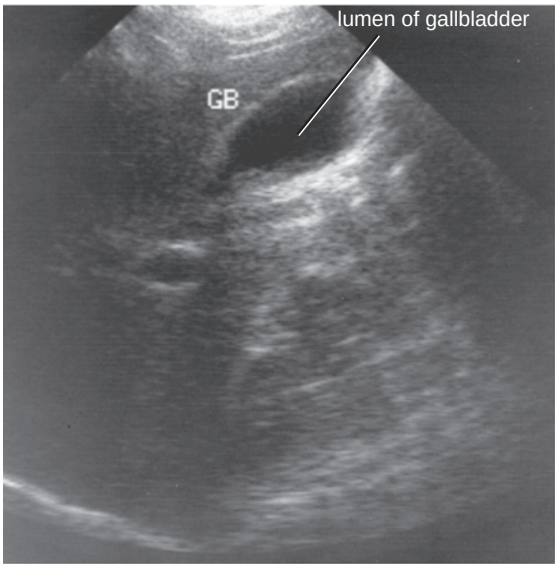

FIGURE 5.54 Longitudinal sonogram of the upper part of the abdomen showing the lumen of the gallbladder. (Courtesy of Dr. M.C. Hill.)

the neck of the gallbladder. The fold is commonly known as the "spiral valve." The function of the spiral valve is to keep the lumen constantly open.

Pancreas

Location and Description

The pancreas is both an exocrine and endocrine gland. The exocrine portion of the gland produces a secretion that contains enzymes capable of hydrolyzing proteins, fats, and carbohydrates. The endocrine portion of the gland, the **pancreatic islets (islets of Langerhans),** produces the hormones **insulin** and **glucagon,** which play a key role in carbohydrate metabolism.

The pancreas is an elongated structure that lies in the epigastrium and the left upper quadrant. It is soft and lobulated and situated on the posterior abdominal wall behind the peritoneum. It crosses the transpyloric plane. The pancreas is divided into a head, neck, body, and tail (Fig. 5.58).

The **head** of the pancreas is disc shaped and lies within the concavity of the duodenum (Fig. 5.58). A part of the head extends to the left behind the superior mesenteric vessels and is called the **uncinate process.**

EMBRYOLOGIC NOTES

Development of the Liver and Bile Ducts

Liver

The liver arises from the distal end of the foregut as a solid bud of entodermal cells (Figs. 5.41 and 5.55). The site of origin lies at the apex of the loop of the developing duodenum and corresponds to a point halfway along the second part of the fully formed duodenum. The **hepatic bud** grows anteriorly into the mass of splanchnic mesoderm called the **septum transversum**. The end of the bud now divides into right and left branches, from which columns of entodermal cells grow into the vascular mesoderm. The paired vitelline veins and umbilical veins that course through the septum transversum become broken up by the invading columns of liver cells and form the **liver sinusoids.** The columns of entodermal cells form the liver cords. The connective tissue of the liver is formed from the mesenchyme of the septum transversum.

The main hepatic bud and its right and left terminal branches now become canalized to form the **common hepatic duct** and the **right** and **left hepatic ducts.** The liver grows rapidly in size and comes to occupy the greater part of the abdominal cavity; the right lobe becomes much larger than the left lobe.

Gallbladder and Cystic Duct

The gallbladder develops from the hepatic bud as a solid outgrowth of cells (Fig. 5.41). The end of the outgrowth expands to form the gallbladder, while the narrow stem remains as the cystic duct. Later, the gallbladder and cystic duct become canalized. The cystic duct now opens into the **common hepatic duct** to form the **bile duct.**

Biliary Atresia

Failure of the bile ducts to canalize during development causes atresia. The various forms of atresia are shown in Figure 5.56. Jaundice appears soon after birth; clay-colored stools and very dark-colored urine are also present. Surgical correction of the atresia should be attempted when possible. If the atresia cannot be corrected, the child will die of liver failure.

Absence of the Gallbladder

Occasionally, the outgrowth of cells from the hepatic bud fails to develop. In these cases, there is no gallbladder and no cystic duct (Fig. 5.57).

Double Gallbladder

Rarely, the outgrowth of cells from the hepatic bud bifurcates so that two gallbladders are formed (Fig. 5.57).

Absence of the Cystic Duct

In the absence of the cystic duct, the entire outgrowth of cells from the hepatic bud develops into the gallbladder and fails to leave the narrow stem that would normally form the cystic duct. The gallbladder drains directly into the bile duct. The condition may not be recognized when performing a cholecystectomy, and the bile duct may be seriously damaged by the surgeon (Fig. 5.57).

Accessory Bile Duct

A small accessory bile duct may open directly from the liver into the gallbladder, which may cause leakage of bile into the peritoneal cavity after cholecystectomy if it is not recognized at the time of surgery (Fig. 5.57).

Congenital Choledochal Cyst

Rarely, a choledochal cyst develops because of an area of weakness in the wall of the bile duct. A cyst can contain 1 to 2 L of bile. The anomaly is important in that it may press on the bile duct and cause obstructive jaundice (Fig. 5.57).

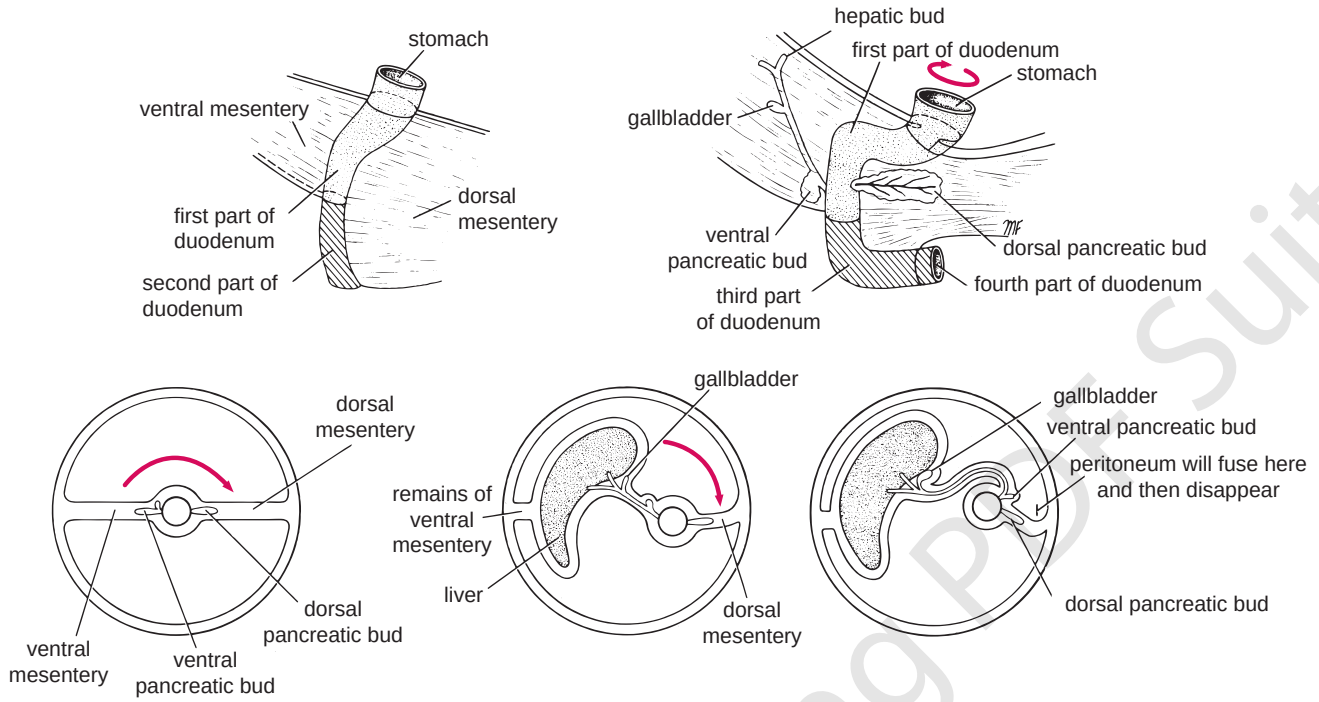

FIGURE 5.55 Development of the duodenum in relation to the ventral and dorsal mesenteries. Stippled area, foregut; cross-hatched area, midgut.

The **neck** is the constricted portion of the pancreas and connects the head to the body. It lies in front of the beginning of the portal vein and the origin of the superior mesenteric artery from the aorta (Fig. 5.26).

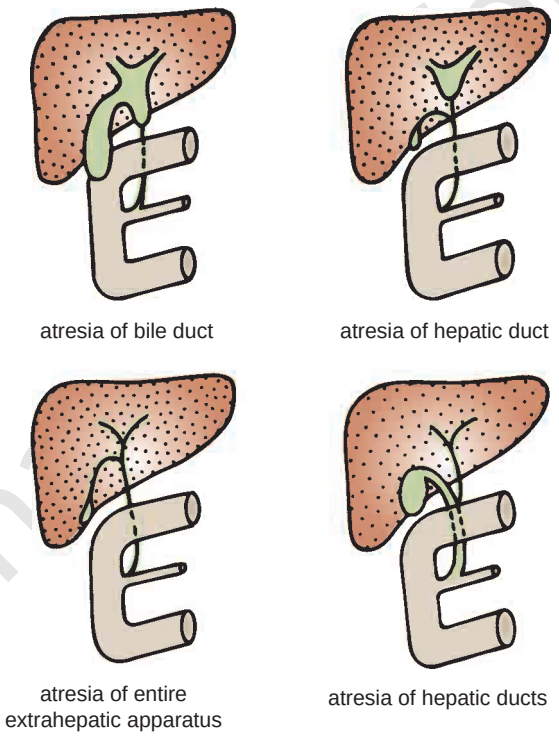

FIGURE 5.56 Some common congenital anomalies of the biliary ducts.

The **body** runs upward and to the left across the midline (Fig. 5.4). It is somewhat triangular in cross section.

The **tail** passes forward in the splenicorenal ligament and comes in contact with the hilum of the spleen (Fig. 5.4).

Relations

- **Anteriorly:** From right to left: the transverse colon and the attachment of the transverse mesocolon, the lesser sac, and the stomach (Figs. 5.4 and 5.6)
- **Posteriorly:** From right to left: the bile duct, the portal and splenic veins, the inferior vena cava, the aorta, the origin of the superior mesenteric artery, the left psoas muscle, the left suprarenal gland, the left kidney, and the hilum of the spleen (Figs. 5.4 and 5.27)

Pancreatic Ducts

The **main duct of the pancreas** begins in the tail and runs the length of the gland, receiving numerous tributaries on the way (Fig. 5.58). It opens into the second part of the duodenum at about its middle with the bile duct on the **major duodenal papilla** (Fig. 5.51). Sometimes, the main duct drains separately into the duodenum.

The **accessory duct** of the pancreas, when present, drains the upper part of the head and then opens into the duodenum a short distance above the main duct on the **minor duodenal papilla** (Figs. 5.51 and 5.58). The accessory duct frequently communicates with the main duct.

Blood Supply

Arteries

The splenic and the superior and inferior pancreaticoduodenal arteries (Fig. 5.26) supply the pancreas.

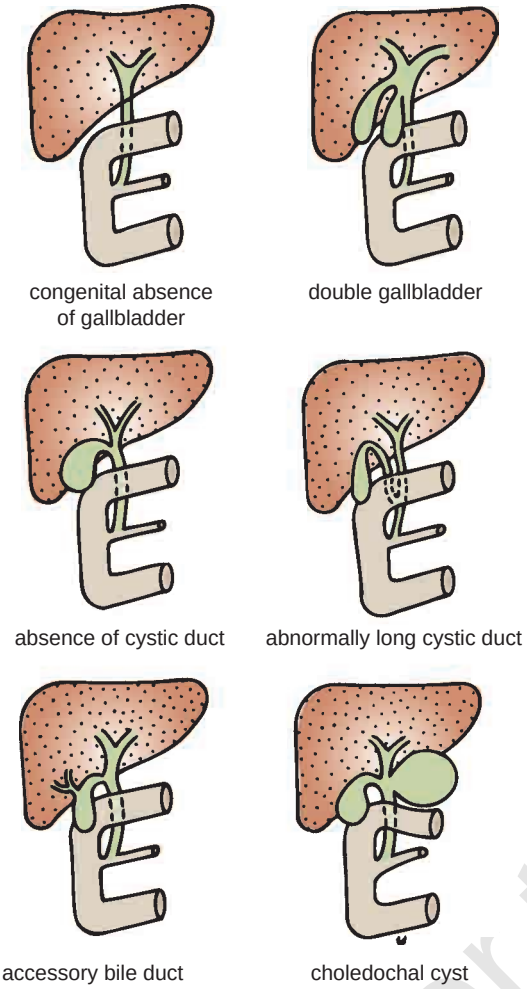

FIGURE 5.57 Some common congenital anomalies of the gallbladder.

Veins

The corresponding veins drain into the portal system.

Lymph Drainage

Lymph nodes are situated along the arteries that supply the gland. The efferent vessels ultimately drain into the celiac and superior mesenteric lymph nodes.

Nerve Supply

Sympathetic and parasympathetic (vagal) nerve fibers supply the area.

Spleen

Location and Description

The spleen is reddish and is the largest single mass of lymphoid tissue in the body. It is oval shaped and has a notched anterior border. It lies just beneath the left half of the diaphragm close to the 9th, 10th, and 11th ribs. The long axis lies along the shaft of the 10th rib, and its lower pole extends forward only as far as the midaxillary line and cannot be palpated on clinical examination (Fig. 5.61).

The spleen is surrounded by peritoneum (Figs. 5.5 and 5.61), which passes from it at the hilum as the gastrosplenic omentum (ligament) to the greater curvature of the stomach (carrying the short gastric and left gastroepiploic vessels). The peritoneum also passes to the left kidney as the splenicorenal ligament (carrying the splenic vessels and the tail of the pancreas).

Relations

- **Anteriorly:** The stomach, tail of the pancreas, and left colic flexure. The left kidney lies along its medial border (Figs. 5.4 and 5.11).

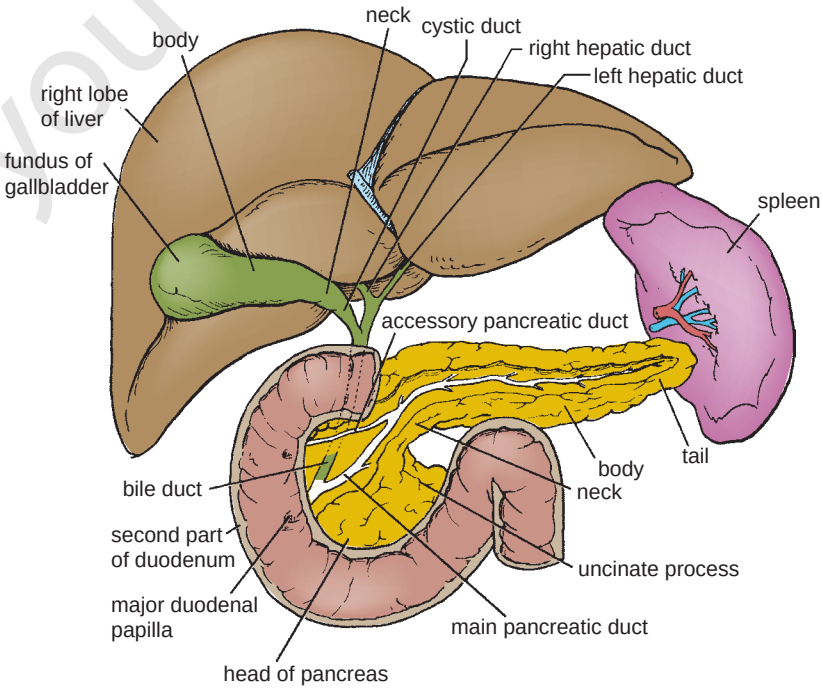

FIGURE 5.58 Different parts of the pancreas dissected to reveal the duct system.

CLINICAL NOTES

Diagnosis of Pancreatic Disease

The deep location of the pancreas sometimes gives rise to problems of diagnosis for the following reasons:

- Pain from the pancreas is commonly referred to the back.
- Because the pancreas lies behind the stomach and transverse colon, disease of the gland can be confused with that of the stomach or transverse colon.
- Inflammation of the pancreas can spread to the peritoneum forming the posterior wall of the lesser sac. This in turn can lead to adhesions and the closing off of the lesser sac to form a pseudocyst.

Trauma of the Pancreas

The pancreas is deeply placed within the abdomen and is well protected by the costal margin and the anterior abdominal wall. However, blunt trauma, such as in a sports injury when a sudden blow to the abdomen occurs, can compress and tear the pancreas against the vertebral column. The pancreas is most commonly damaged by gunshot or stab wounds.

Damaged pancreatic tissue releases activated pancreatic enzymes that produce the signs and symptoms of acute peritonitis.

Cancer of the Head of the Pancreas and the Bile Duct

Because of the close relation of the head of the pancreas to the bile duct, cancer of the head of the pancreas often causes obstructive jaundice.

The Pancreatic Tail and Splenectomy

The presence of the tail of the pancreas in the splenicorenal ligament sometimes results in its damage during splenectomy. The damaged pancreas releases enzymes that start to digest surrounding tissues, with serious consequences.

EMBRYOLOGIC NOTES

Development of the Pancreas

The pancreas develops from a **dorsal** and **ventral bud** of entodermal cells that arise from the foregut. The dorsal bud originates a short distance above the ventral bud and grows into the dorsal mesentery. The ventral bud arises in common with the hepatic bud, close to the junction of the foregut with the midgut (Fig. 5.41). A canalized duct system now develops in each bud. The rotation of the stomach and duodenum, together with the rapid growth of the left side of the duodenum, results in the ventral bud's coming into contact with the dorsal bud, and fusion occurs (Fig. 5.59).

Fusion also occurs between the ducts, so that the **main pancreatic duct** is derived from the entire ventral pancreatic duct and the distal part of the dorsal pancreatic duct. The main pancreatic duct joins the bile duct and enters the second part of the duodenum. The proximal part of the dorsal pancreatic duct may persist as an **accessory duct,** which may or may not open into the duodenum about 0.75 in. (2 cm) above the opening of the main duct.

Continued growth of the entodermal cells of the now-fused ventral and dorsal pancreatic buds extends into the surrounding mesenchyme as columns of cells. These columns give off side branches, which later become canalized to form collecting ducts. Secretory acini appear at the ends of the ducts.

The **pancreatic islets** arise as small buds from the developing ducts. Later, these cells sever their connection with the duct system and form isolated groups of cells that start to secrete **insulin** and **glucagon** at about the 5th month.

The inferior part of the head and the uncinate process of the pancreas are formed from the ventral pancreatic bud; the superior part of the head, the neck, the body, and the tail of the pancreas are formed from the dorsal pancreatic bud (Fig. 5.59).

Entrance of the Bile Duct and Pancreatic Duct into the Duodenum

As seen from development, the bile duct and the main pancreatic duct are joined to one another. They pass obliquely through the wall of the second part of the duodenum to open on the summit of the **major duodenal papilla,** which is surrounded by the **sphincter of Oddi** (Fig. 5.52). In some individuals, they pass separately through the duodenal wall, although in close contact, and open separately on the summit of the duodenal papilla. In other individuals, the two ducts join and form a common dilatation, the **hepatopancreatic ampulla (ampulla of Vater).** This opens on the summit of the duodenal papilla.

Anular Pancreas

In anular pancreas, the ventral pancreatic bud becomes fixed so that, when the stomach and duodenum rotate, the ventral bud is pulled around the right side of the duodenum to fuse with the dorsal bud of the pancreas, thus encircling the duodenum (Fig. 5.60). This may cause obstruction of the duodenum, and vomiting may start a few hours after birth. Early surgical relief of the obstruction is necessary.

Ectopic Pancreas

Ectopic pancreatic tissue may be found in the submucosa of the stomach, duodenum, small intestine (including Meckel's diverticulum), and gallbladder, and in the spleen. It is important in that it may protrude into the lumen of the gut and be responsible for causing intussusception.

Congenital Fibrocystic Disease

Basically, congenital fibrocystic disease in the pancreas is caused by an abnormality in the secretion of mucus. The mucus produced is excessively viscid and obstructs the pancreatic duct, which leads to pancreatitis with subsequent fibrosis. The condition also involves the lungs, kidneys, and liver.

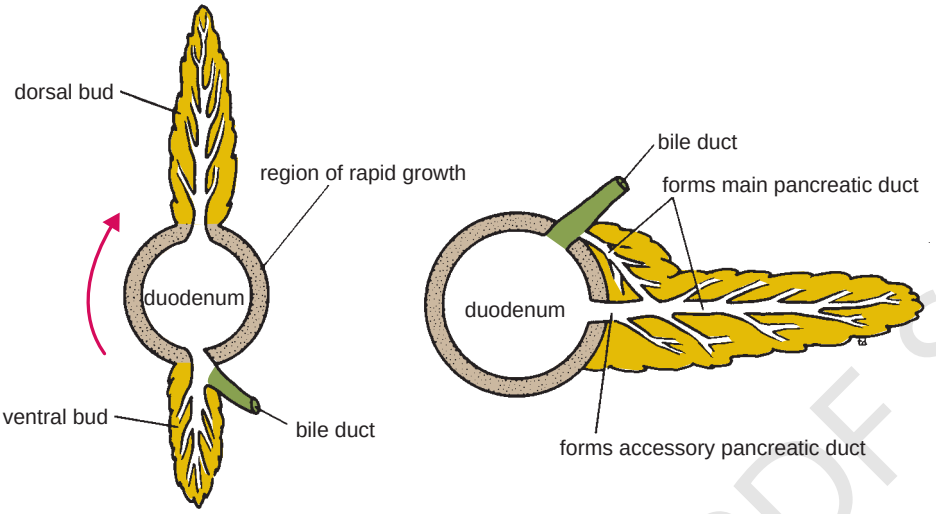

FIGURE 5.59 The rotation of the duodenum and the unequal growth of the duodenal wall lead to the fusing of the ventral and dorsal pancreatic buds.

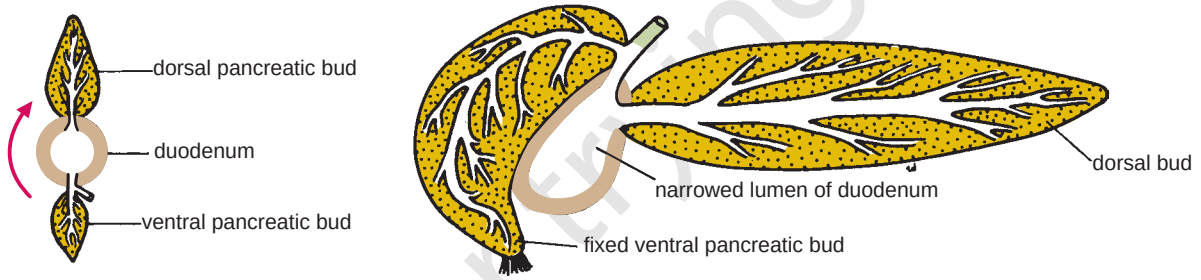

FIGURE 5.60 Formation of the anular pancreas, producing duodenal obstruction. Note the narrowing of the duodenum.

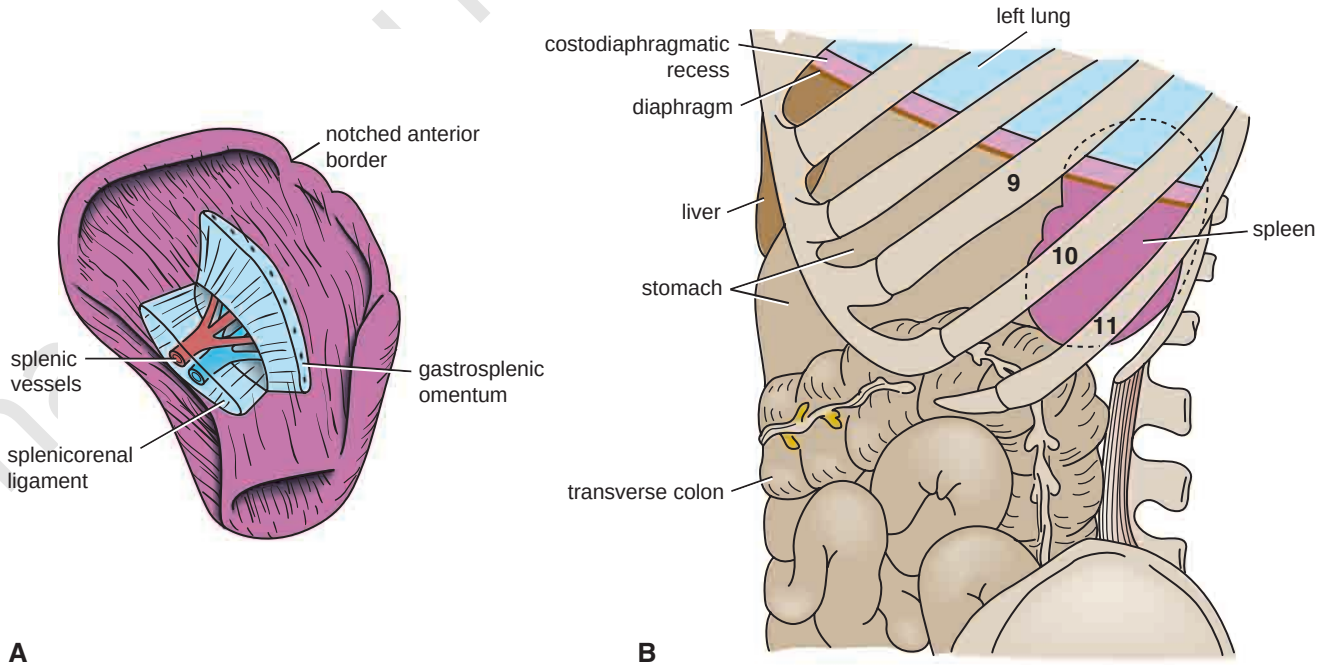

FIGURE 5.61 Spleen. **A.** It is oval shaped and has a notched anterior border. **B.** Shows relation of spleen to adjacent structures.

- **Posteriorly:** The diaphragm; left pleura (left costodiaphragmatic recess); left lung; and 9th, 10th, and 11th ribs (Figs. 5.11 and 5.61).

Blood Supply

Arteries

The large splenic artery is the largest branch of the celiac artery. It has a tortuous course as it runs along the upper border of the pancreas. The splenic artery then divides into about six branches, which enter the spleen at the hilum.

Veins

The splenic vein leaves the hilum and runs behind the tail and the body of the pancreas. Behind the neck of the pancreas, the splenic vein joins the superior mesenteric vein to form the portal vein.

Lymph Drainage

The lymph vessels emerge from the hilum and pass through a few lymph nodes along the course of the splenic artery and then drain into the celiac nodes.

Nerve Supply

The nerves accompany the splenic artery and are derived from the celiac plexus.

CLINICAL NOTES

Splenic Enlargement

A pathologically enlarged spleen extends downward and medially. The left colic flexure and the phrenicocolic ligament prevent a direct downward enlargement of the organ. As the enlarged spleen projects below the left costal margin, its notched anterior border can be recognized by palpation through the anterior abdominal wall.

The spleen is situated at the beginning of the splenic vein, and in cases of portal hypertension it often enlarges from venous congestion.

Trauma to the Spleen

Although anatomically the spleen gives the appearance of being well protected, automobile accidents of the crushing or run-over type commonly produce laceration of the spleen. Penetrating wounds of the lower left thorax can also damage the spleen.

EMBRYOLOGIC NOTES

Development of the Spleen

The spleen develops as a thickening of the mesenchyme in the dorsal mesentery (Fig. 5.46). In the earliest stages, the spleen consists of a number of mesenchymal masses that later fuse. The notches along its anterior border are permanent and indicate that the mesenchymal masses never completely fuse.

(continued)

The part of the dorsal mesentery that extends between the hilum of the spleen and the greater curvature of the stomach is called the **gastrosplenic omentum;** the part that extends between the spleen and the left kidney on the posterior abdominal wall is called the **splenicorenal ligament.** The spleen is supplied by a branch of the foregut artery (celiac artery), the **splenic artery.**

Supernumerary Spleen

In 10% of people, one or more supernumerary spleens may be present, either in the gastrosplenic omentum or in the splenicorenal ligament. Their clinical importance is that they may hypertrophy after removal of the major spleen and be responsible for a recurrence of symptoms of the disease for which splenectomy was initially performed.

Retroperitoneal Space

The retroperitoneal space lies on the posterior abdominal wall behind the parietal peritoneum. It extends from the 12th thoracic vertebra and the 12th rib to the sacrum and the iliac crests below (Fig. 5.62).

The floor or posterior wall of the space is formed from medial to lateral by the psoas and quadratus lumborum muscles and the origin of the transversus abdominis muscle. Each of these muscles is covered on the anterior surface by a definite layer of fascia. In front of the fascial layers is a variable amount of fatty connective tissue that forms a bed for the suprarenal glands, the kidneys, the ascending and descending parts of the colon, and the duodenum. The retroperitoneal space also contains the ureters and the renal and gonadal blood vessels.