

# Anatomy of the pancreas and spleen

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## Abstract

The pancreas is a large, retroperitoneal organ situated immediately behind the posterior wall of the lesser sac, in the floor of the supracolic compartment of the abdominal cavity. Although principally an exocrine gland, the pancreas also performs crucially important endocrine functions. The exocrine pancreas secretes digestive enzymes. These are produced by the pancreatic acini and released into an elaborate ductal system which eventually opens into the second part of the duodenum. The endocrine component of the pancreas is represented by the islets of Langerhans that are present diffusely in the pancreatic substance. The islets are microscopic collections of cells whose secretions include pro-insulin and glucagon; hormones of vital importance in carbohydrate metabolism. Its deep location and its close topographical relationship to several vital structures make pancreatic surgery both challenging and hazardous. A sound appreciation of the topographical, vascular and ductal anatomy of the pancreas is fundamental to the successful surgical management of pancreatic cancers, congenital malformations of the pancreas and various surgical complications of acute pancreatitis.

The spleen is the largest lymphoid organ in the body. It is situated deep in the left hypochondrium, wedged between the gastric fundus, left hemidiaphragm and left kidney. Trauma, lymphoid neoplasia, gastric cancers, portal hypertension and idiopathic thrombocytopenia may necessitate splenectomy. A sound knowledge of the surgical and functional anatomy of the spleen is essential if splenectomy is to be performed safely and effectively.

**Keywords** Islets of Langerhans; lesser sac; pancreatic ducts; portal vein; splenic artery and vein; splenic hilum

## The pancreas

The pancreas is an elongated, soft, flat, lobulated and yellowish gland that lies on the posterior abdominal wall, more-or-less transversely. It is a retroperitoneal structure and possesses a thin capsule. For descriptive purposes the pancreas is divided into a head, neck, body and tail. The head and tail mark the right and left extremities of the gland, respectively (Figure 1). The head and neck of the pancreas lie slightly to the right of the midline while the tail is to the left of the midline. The body of the pancreas passes to the left, inclining slightly upwards to become continuous with the tail. As it passes from right to left, the body of the pancreas arches across in front of the aorta and vertebral column, approximately in the transpyloric plane at the level of the first lumbar vertebra. The deep location of the pancreas and the presence of various anteriorly situated viscera render the

pancreas inaccessible to physical examination. The pancreas has a dual function. Besides being an important accessory exocrine digestive gland, the pancreas possesses an important endocrine component made up of the million or so islets of Langerhans that are distributed throughout the substance of the pancreas.

## Topographical relations of the pancreas

The head of the pancreas is the broadest part of the pancreas and lies snugly within the C-curve of the duodenum. Superomedially the head is continuous with the neck of the pancreas, which in turn is continuous with the body. Projecting inferomedially from the head is the uncinat process. The latter insinuates itself behind the superior mesenteric vessels as the latter descend obliquely behind the body and neck of the pancreas into the mesenteric root (Figure 1). The structures related to the anterior aspect of the pancreas are as follows.

The root of the transverse mesocolon has a continuous attachment to the ventral surface of the head and neck of the pancreas and along the anterior surface of the body of the pancreas adjacent to its lower border. Superior to the line of attachment of the transverse mesocolon, the lesser sac is an immediate anterior relation of the pancreas. The lesser sac lies between the pancreas and the posterior surface of the stomach.

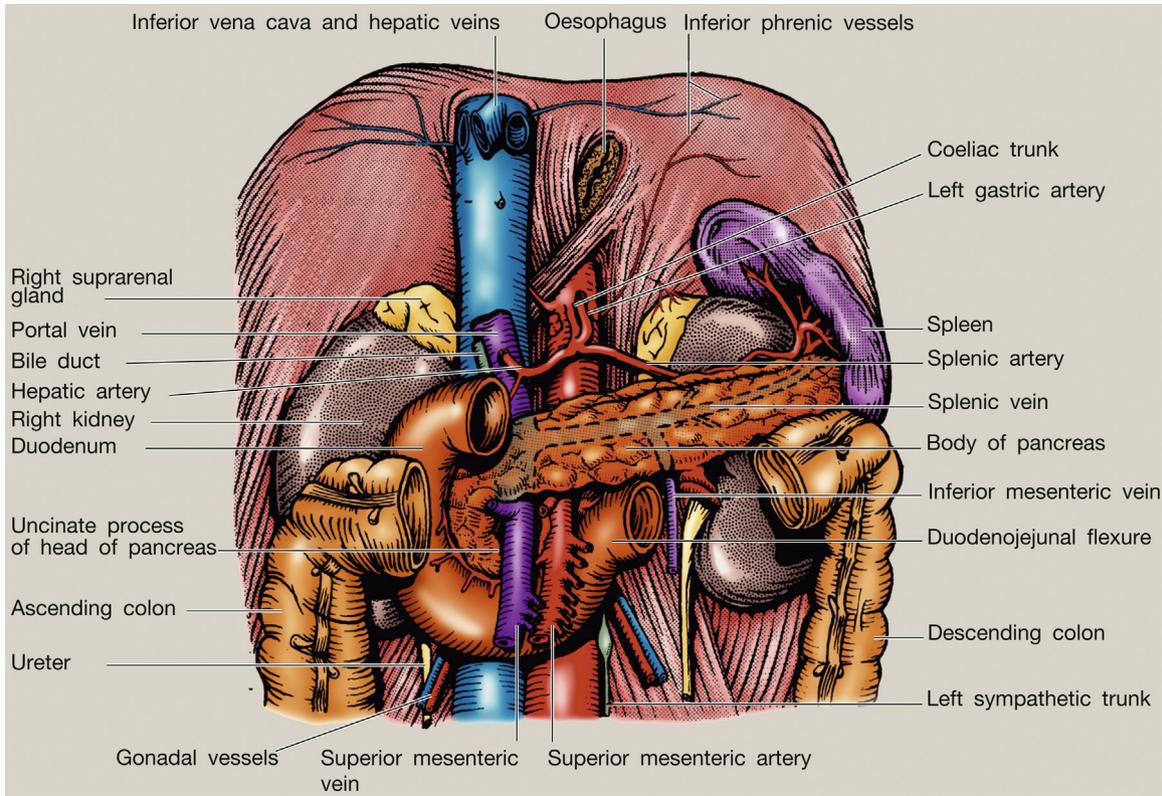
The posterior relations of the pancreas (Figure 1), moving from right to left, are as follows.

The head of the pancreas overlies the inferior vena cava which at this level receives the right and left renal veins. Immediately behind the head of the pancreas is the lower end of the common bile duct before the latter tunnels into the head of the pancreas to join the main pancreatic duct. The neck of the pancreas lies immediately in front of the commencement of the portal vein which is formed by the union of the splenic and superior mesenteric veins (Figure 1). The body of the pancreas, immediately medial to the neck, overlies the abdominal aorta and the origin of the superior mesenteric artery. Further to the left the body overlies the left crus of the diaphragm, the left renal hilum and left suprarenal gland (Figure 1). The splenic vein runs immediately posterior to the length of the body of the pancreas and receives the inferior mesenteric vein 2–3 cm before joining the superior mesenteric vein (see Figure 3). Just lateral to the left renal hilum the tail of the pancreas extends into the lienorenal ligament.

## Arterial supply, venous drainage and lymphatic drainage of the pancreas

The head and neck of the pancreas are supplied by two pancreaticoduodenal arterial arcades; one anterior and one posterior (Figure 2). Each arcade is fed by the superior and inferior pancreaticoduodenal arteries. The arcades lie between the convex periphery of the pancreatic head and the concave inner margin of the duodenum. The superior pancreaticoduodenal arteries are branches of the gastroduodenal artery which in turn is a branch of the common hepatic artery. The inferior pancreaticoduodenal arteries are the earliest branches of the superior mesenteric artery. The pancreaticoduodenal arcades thus represent anastomoses between the coeliac and superior mesenteric arteries. As implied in their names, the pancreaticoduodenal arcades also supply the adjacent duodenum. Ligation or interruption of the arcades will result in significant devascularization of the duodenum. The body and tail of the

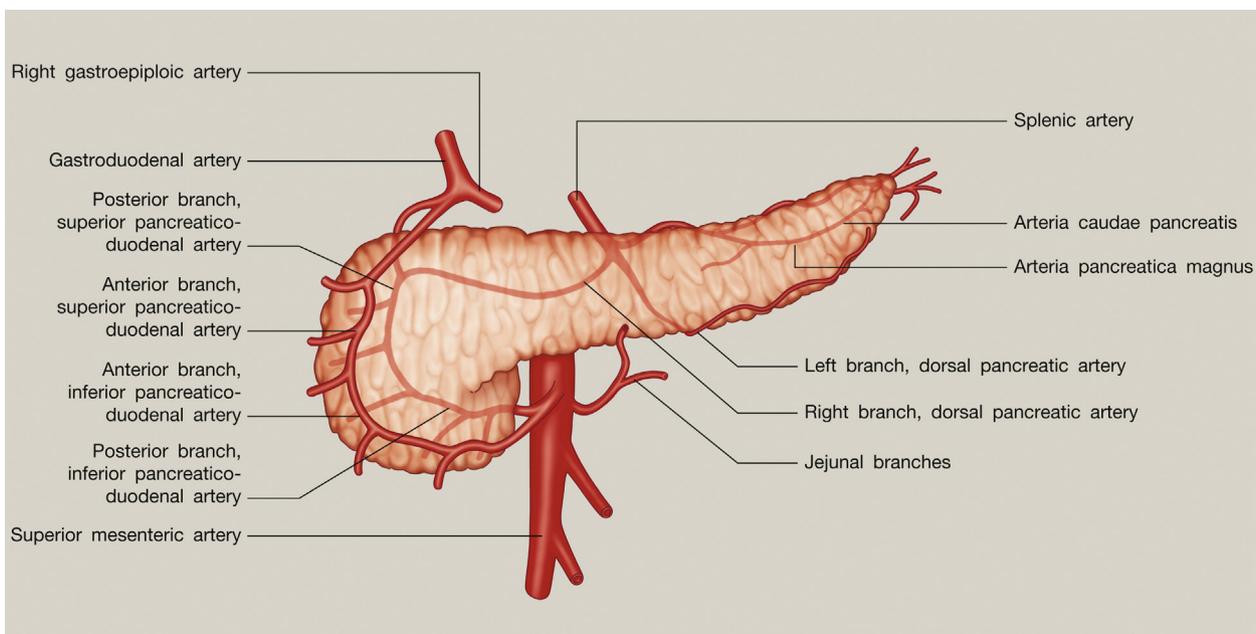
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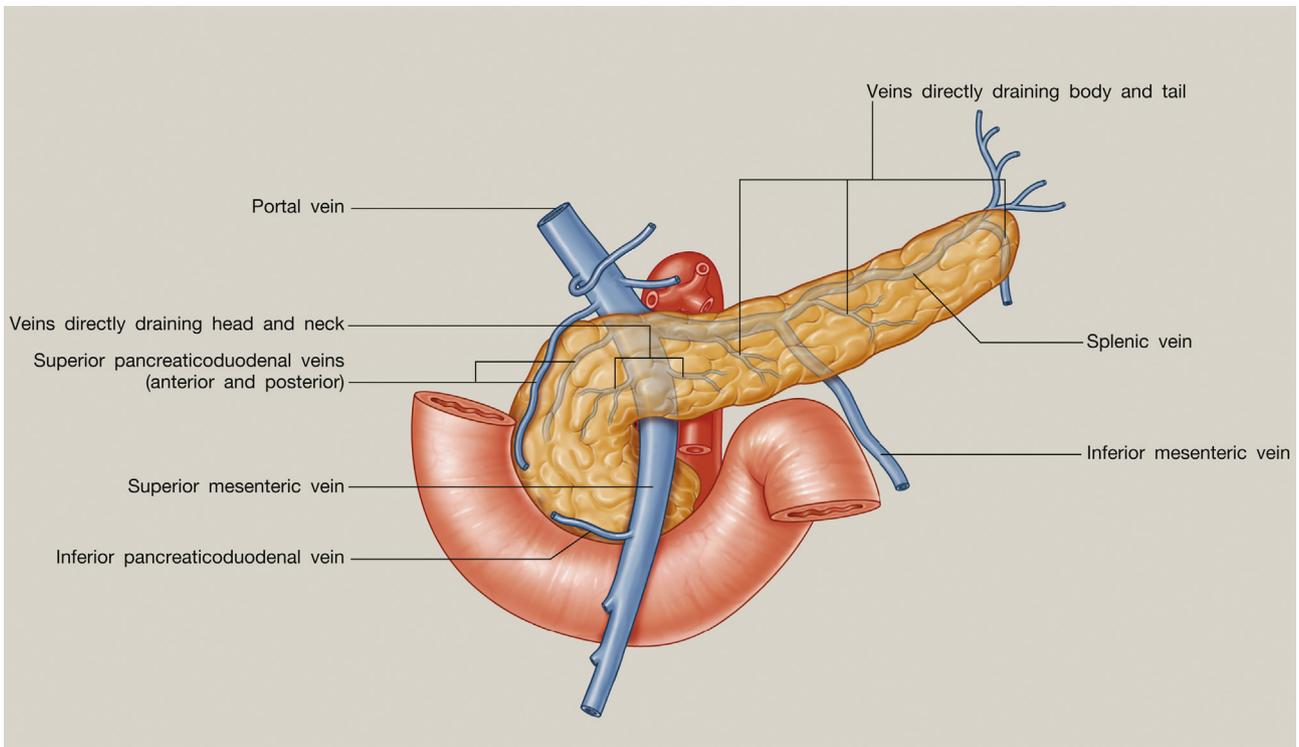
**Figure 1** Topographical relations of the pancreas

pancreas are supplied by multiple branches of the splenic artery. The latter is a major terminal branch of the coeliac trunk. It runs tortuously and to the left, along the upper border of the body and tail of the pancreas (Figure 2) before entering the splenorenal ligament to reach the splenic hilum. The splenic artery gives off multiple branches which enter the dorsal surface of the pancreas (Figure 2).

Venous drainage of the pancreas is to the portal system (Figure 3). The portal vein is formed immediately behind the neck of the pancreas by the confluence of the splenic vein and superior mesenteric vein (Figure 3). The splenic vein, unlike the splenic artery, pursues a straight course. Commencing in the vicinity of the splenic hilum, the splenic vein adheres to the posterior surface of the tail and body of the pancreas. Often it is



**Figure 2** Arterial supply of pancreas



**Figure 3** Venous drainage of pancreas

contained, at least for part of its length, in a fibrous tunnel that is partially embedded in the pancreas. The splenic vein receives five to twelve tributaries from the tail and body of the pancreas, besides receiving the inferior mesenteric vein (Figure 3). The head and neck of the pancreas drain into the superior and inferior pancreaticoduodenal veins. The superior veins drain partly into the right gastroepiploic vein and partly into the portal vein directly. The inferior pancreaticoduodenal veins drain into the superior mesenteric vein. Thus, regardless of the route, the entire venous drainage of the pancreas reaches the portal vein eventually.

Lymphatic vessels draining the pancreas accompany the pancreatic arteries. The body and tail of the pancreas drain into the retropancreatic nodes. The upper half of the head and neck drains into the coeliac lymph nodes while the lower half of the head drains into the superior mesenteric nodes.

#### Ductal system of the pancreas (Figure 4)

The main duct of the gland, the duct of Wirsung, runs the length of the gland and usually joins with the termination of the common bile duct to form the ampulla of Vater that opens into the posteromedial aspect of the mucosa of the second part of the duodenum at the major duodenal papilla. The accessory pancreatic duct, the duct of Santorini, passes from the upper part of the head and opens into the duodenal mucosa at the minor papilla about 2 cm proximal to the opening of the major duct (Figure 4).

#### Microscopic structure

The pancreas is a finely lobulated gland contained within a delicate fibrous capsule. The lobules are composed of acini of serous secretory cells. The acini comprise the exocrine part of the

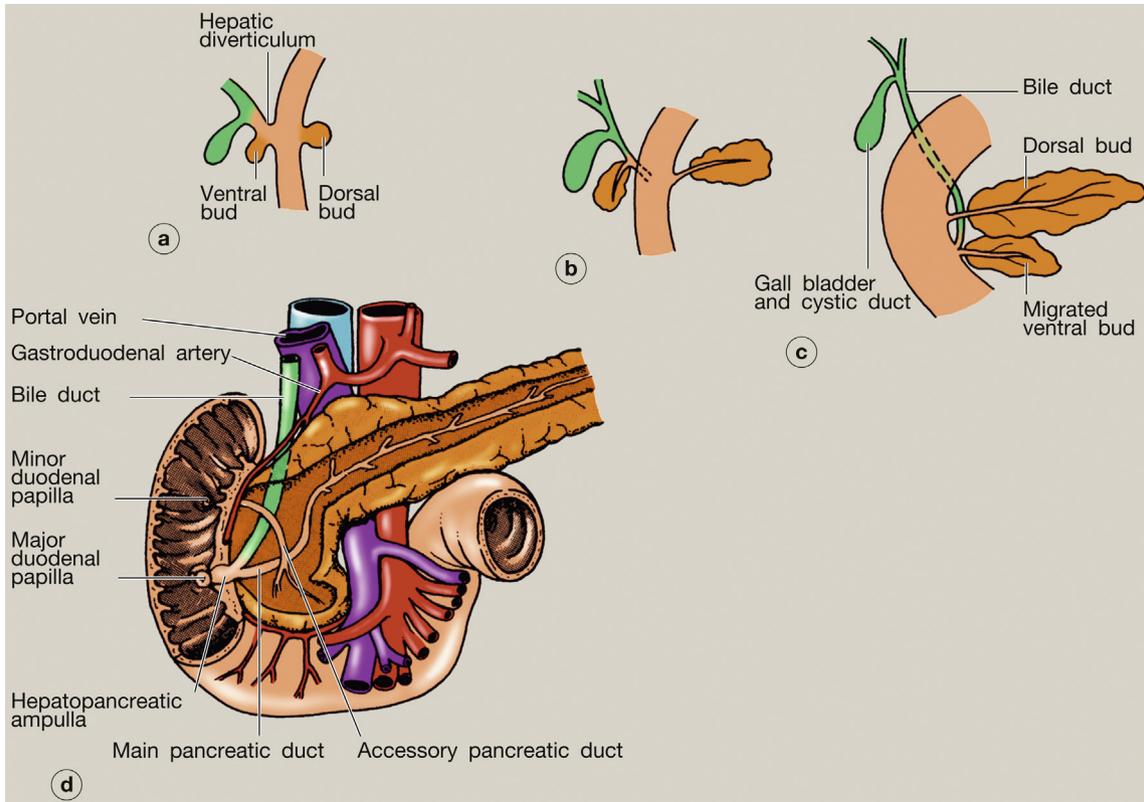
pancreas and discharge their secretions via ductules into the principal ducts. Between the acini lie the islets of Langerhans. The islets are discrete aggregations of different secretory cell types, distinguishable by histochemical staining. The alpha cells of the islets secrete glucagon; the beta cells secrete pro-insulin (a congener of insulin). A third cell type, the delta cell, secretes somatostatin.

#### Development

The pancreas is formed by two endodermal buds which arise from the duodenum: a large dorsal bud and a relatively small ventral bud that is closely related to the developing bile duct. The subsequent rotation of the duodenum to the right results in the ventral bud migrating posteriorly and coming to lie inferior and posterior to the dorsal bud. This is followed by fusion of the duct systems and parenchyma of the two buds. The ventral bud gives rise to the uncinata process and lower part of the head of pancreas. The dorsal bud gives rise to the remainder of the gland. The entire ventral pancreatic duct and the distal part of the dorsal pancreatic duct give rise to the main pancreatic duct (of Wirsung), which empties into the duodenum through a shared opening with the common bile duct. The proximal part of the dorsal duct of the pancreas forms the accessory duct of Santorini.

#### The spleen (Figures 1 and 5)

The spleen is the largest lymphoid organ in the body and lies deep in the left upper quadrant of the abdominal cavity. The healthy spleen, in life, is a soft, friable organ that is dark purple in colour with a smooth surface. This contrasts strikingly with its appearance and texture in the embalmed cadaver, in whom the spleen is a firm, rigid and relatively pale structure. The spleen is



**Figure 4** The ductal system of the pancreas

variable in size, shape and weight. Its length, width and thickness are approximately 12, 7 and 3 cm respectively. Its weight, on average, is 150 g.

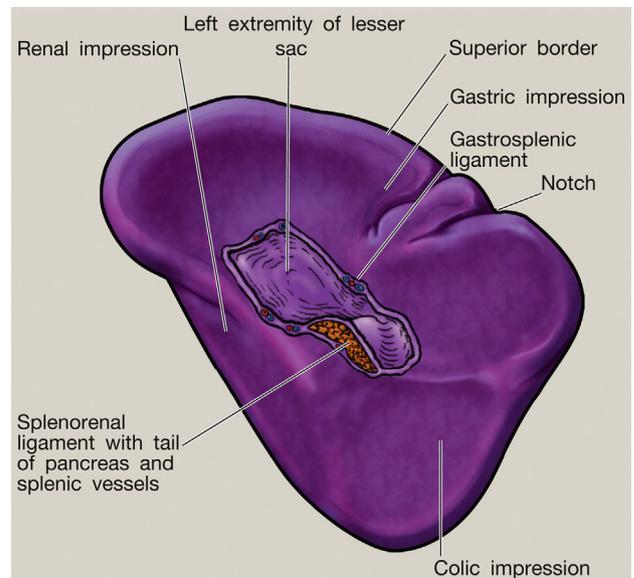
The spleen possesses a thin capsule, outside which it is enveloped almost completely in visceral peritoneum, and has a moderate degree of mobility. The spleen is in the shape of an irregular, somewhat elongated wedge and may be pictured as having a convex lateral surface facing the left hemidiaphragm, and a reciprocally concave medial surface that is related to the gastric fundus, tail of the pancreas and the anterior surface of the left kidney (Figure 5). The medial surface is, therefore, also termed the visceral surface. The lateral and medial surfaces of the spleen are demarcated from each other by superior and inferior borders. The anterior and posterior extremities of the spleen are termed the anterior and posterior poles, respectively. The long axis of the spleen corresponds approximately to the line of the left 10th rib, and the location of the spleen may be indicated on the surface over the posterolateral aspects of the left 9th, 10th and 11th ribs. The posterior pole of the spleen lies in, or close to, the left paravertebral gutter. The anterior pole of the spleen normally does not extend anterior to the mid-axillary line. Consequently the spleen is not palpable in the normal subject. Indeed, the spleen must be three to four times larger than its normal size before its anterior pole is palpable just inferior to the left costal margin.

**Topographical relations of the spleen**

Posterolaterally, the spleen is related to the inferior surface of the left hemidiaphragm being separated from the latter by the upper, left limit of the peritoneal cavity. The left hemidiaphragm intervenes between the spleen on the one side and the pleura, base

of left lung and the 9th, 10th and 11th left ribs, on the other. It is easy to imagine a stab injury of the posterolateral aspect of the left lower chest resulting in a pneumothorax, a lacerated lung and a torn spleen.

The posterior pole of the spleen lies in or just lateral to the left paravertebral gutter, level with the first lumbar vertebra. The anterior pole of the spleen lies immediately superolateral to the splenic flexure of the colon (see Figure 1) and just above the phrenicocolic ligament. The latter is a short double-layered



**Figure 5** Visceral surface of spleen

peritoneal fold that extends laterally and upwards from the splenic flexure to become continuous with the peritoneum on the inferior surface of the left hemidiaphragm.

The relations of the medial surface of the spleen are best appreciated by reviewing briefly the embryological development of the spleen. The spleen is a mesodermal structure formed originally in the left leaf of the dorsal mesogastrium (the dorsal mesentery of the stomach). Further growth of the embryonic splenic mass is directed leftward causing the dorsal mesogastrium to be stretched to the left side. This results in the formation of two double layered peritoneal folds. One is the gastrosplenic (gastrosplenic) ligament that connects the visceral aspect of the spleen to the greater curvature of the stomach, while the other fold the splenorenal (lienorenal) ligament runs from the splenic hilum towards the anterior surface of the left kidney. These so-called ligaments convey blood vessel and lymphatics.

Part of the medial surface of the spleen between these two folds forms the left lateral extremity of the lesser sac (Figure 5).

The medial surface of the spleen features the splenic hilum which is a cleft through which vessels enter or leave the spleen. The peritoneum which envelops the splenic capsule, surrounds the hilum and from the hilar margin it extends posteromedially to the left kidney as the splenorenal ligament (Figure 5). The medial surface of the spleen, anterior to the hilum, is related to the splenic flexure of the colon. Anterosuperior to the hilum, the medial surface is related to the upper part of the greater curvature and fundus of the stomach. Posteroinferior to the hilum, the medial surface of the spleen is related to the anterolateral surface of the left kidney (Figures 1 and 5).

### Blood supply of the spleen

The spleen derives its arterial supply solely from the splenic artery. The latter, as already seen, runs along the upper border of the body and tail of the pancreas and enters the splenorenal ligament accompanied by the splenic vein and often by the pancreatic tail. Either at the splenic hilum or more proximally within the splenorenal ligament, the splenic artery bifurcates into inferior and superior divisions. Just before entering the splenic hilum, either the main trunk of the splenic artery or one or other of the terminal divisions of the splenic artery gives rise to the short gastric arteries and the left gastroepiploic artery. These arteries, accompanied by veins, reach the greater curvature of the stomach by running within the gastrosplenic ligament. The short gastric arteries travel proximally to the gastric fundus, while the left gastroepiploic artery travels distally, along the greater curvature, to meet the right gastroepiploic artery.

It is now well-known and acknowledged that the spleen is made up of well-delineated segments determined by the segmental arrangement of the splenic artery branches. Upper and lower polar segments of the spleen are fairly constant. In addition, the spleen possesses a variable number (between two and four) of 'central segments'. These segmental branches of the splenic artery were not previously thought to be significant. However, now that the advantages of splenic conservation have been established beyond doubt, there is increasing recognition that ligation of segmental branches allows segmental splenectomies to be performed safely.

The venous drainage of the spleen displays as much variability as the arterial arrangement. A variable number of venous tributaries (between three and six) emerge from the splenic hilum and unite within the splenorenal ligament to form the trunk of the splenic vein.

The course and termination of the splenic vein have already been reviewed earlier in this article. The lymphatic drainage of the spleen is to lymph nodes in the splenic hilum and to the retropancreatic nodes and thence to the preaortic coeliac lymph nodes.

Accessory spleens (also known as splenunculi, supernumerary spleens or splenules) are fairly common. Based on observations in the dissection room and abdominal CT scans of patients it has been estimated that accessory spleens are present in 20–30% of individuals. They appear as grape-sized nodules, and are located most commonly near the splenic hilum or more proximally alongside the splenic vessels. Occasionally they may be found in the greater omentum, small bowel mesentery or even on the surface of the ovary or testis. They are, of course, of little consequence in splenic trauma. However, if unnoticed or left behind, following splenectomy for conditions such as thrombocytopenic purpura or autoimmune haemolytic anaemia, the retained splenunculi may result in persistence of the original symptoms for which the splenectomy was undertaken. ♦

### FURTHER READING

- Ellis H, Mahadevan V. *Clinical anatomy*. 13th edn. Wiley Blackwell, 2013; 110–3.
- Moore KL, Dalley AF, Agur Wolters AMR. *Clinically oriented anatomy*. 7th edn. Kluwer/Lippincott Williams & Wilkins, 2014; 263–8.
- Sadler TW. *Langman's medical embryology*. 12th edn. Wolters Kluwer/Lippincott Williams & Wilkins, 2012; 212–4. 221–2.
- Sinnatamby CS. *Last's anatomy: regional and applied*. 12th edn. Churchill Livingstone Elsevier, 2011; 267–72.