Anatomy of the pancreas and spleen

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Abstract

The pancreas is a retroperitoneal organ located at the level of the transpyloric plane. Descriptively it can be divided into the head, neck, body, and tail. It has several important anatomical relations, including the formation of the portal vein posteriorly. The main pancreatic duct drains secretions by combining with the common bile duct at the ampulla of Vater before opening into the duodenum via the major duodenal papilla. The pancreatic arterial supply is via the superior and inferior pancreaticoduodenal and splenic arteries. Acute pancreatitis is most commonly caused by gallstones and ethanol and can range in severity. Management focuses on symptom control, although interventions may be required for subsequent complications. Ductal adenocarcinoma accounts for over 85% of pancreatic neoplasms. The only curative treatment is surgical resection. The spleen lies within the left upper quadrant of the abdomen and is the largest lymphoid organ. Anatomically it can be divided into a superior and inferior pole, visceral and diaphragmatic surface, and superior, inferior, and intermediate borders. At the hilum, peritoneal reflections create two ligaments; the gastrosplenic and splenorenal. The blood supply is via the splenic artery and vein. Splenectomies can be considered in a variety of pathologies, including trauma, haematological conditions, and neoplasia.

Keywords Anatomy; pancreas; pancreatic adenocarcinoma; pancreatitis; spleen; splenectomy; surgery

Pancreas

Anatomy and relations

The pancreas is an unpaired, elongated, finely lobulated organ with a thin fibrous capsule, which has both endocrine and exocrine features. The lobules are comprised of acini cells with digestive secretions that classify the pancreas as an accessory exocrine digestive gland. These secretions travel through a ductal system into the duodenum. Between the acini lie the islets of Langerhans, which form the endocrine portion of the pancreas. The islets consist of four types of endocrine cells: alpha cells secreting glucagon, beta cells secreting insulin, delta cells secreting somatostatin, and pancreatic polypeptide cells secreting pancreatic polypeptide.

Descriptively, the pancreas can be divided into a head, neck, body, and tail and is found at the level of the transpyloric plane at the level of the L1 vertebrae. It lies on the posterior abdominal wall as a retroperitoneal organ, except for the tail which is intraperitoneal within the splenorenal ligament.

The pancreas extends from the duodenum to the spleen, lying predominantly in the midline, with a slight oblique angle which sees the tail lie slightly superior to the head. Due to the oblique angle, the pancreas cannot be imaged in its entirety in a single slice of transverse cross-sectional imaging.

The pancreas has several important anatomical relations (Figure 1):

1. Head:

The head of the pancreas is the thickest section of the organ and lies within the C-shape curve of the duodenum. It sits anterior to the inferior vena cava (IVC) at the level in which the right and left renal veins join the IVC. It also lies to the right of the superior mesenteric artery and vein. The head of the pancreas extends inferomedially to form the uncinate process. At the point of the uncinate process the superior mesenteric vessels pass anteriorly to the pancreas.

2. Neck:

The neck of the pancreas lies between the head and the body, with a groove in its posterior surface as it passes anteriorly to the superior mesenteric artery and vein. Importantly, it is at the level of the neck of the pancreas that the superior mesenteric vein and splenic vein join to form the hepatic portal vein.

3. Body and Tail:

The body forms the main part of the pancreas and crosses the midline. It lies anterior to the abdominal aorta and the origin of the superior mesenteric artery. It has a close relation to the splenic vessels, with the splenic artery running superiorly and the splenic vein immediately posterior, including the union of the inferior mesenteric vein to the splenic vein. As the body of the pancreas continues left laterally, it passes anteriorly to the left crus of the diaphragm, the left renal hilum, and left suprarenal gland. As it transitions into the tail of the pancreas, it extends into the splenorenal ligament along with the splenic vessels and becomes intraperitoneal.

In addition to the above, the transverse mesocolon has a continuous attachment to the anterior surface of the pancreas along its inferior border. Superior to this line of attachment and anterior to the pancreas, the lesser sac can also be found separating the pancreas and the stomach.

Ductal system

Travelling through the entirety of the pancreas, from tail to head, is the main pancreatic duct (also known as the duct of Wirsung). The pancreatic duct typically measures 1 mm at the tail, 2 mm at the body, and 3 mm at the head. The pancreatic duct terminates by joining the common bile duct, which travels posterior to the head of the pancreas, to form the hepatopancreatic ampulla (also known as the ampulla of Vater). This opens into the posteromedial aspect of the second part of the duodenum at the major duodenal papilla. The release of secretions from this ductal system into the duodenum is controlled by the sphincter of Oddi, a smooth muscle sphincter, which also prevents reflux of duodenal contents into the hepatopancreatic ducts. The pancreas also contains an accessory duct (or duct of Santorini), which passes from the head of the pancreas and opens directly into the duodenum at the minor ampulla. This opening is 2 cm proximal to the opening of the major duct.

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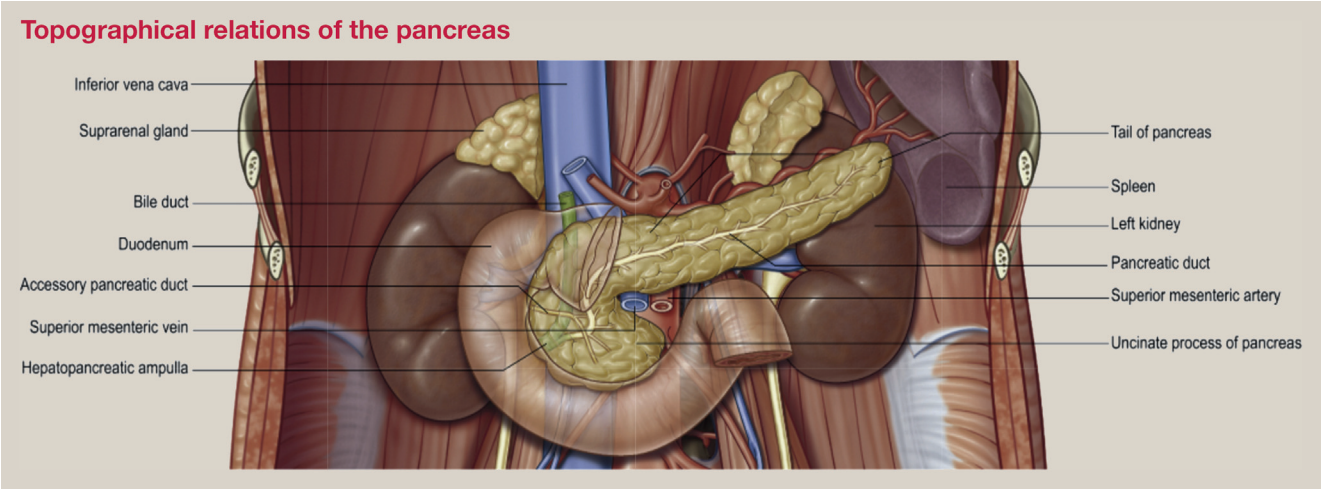

Figure 1

Blood supply and lymphatics

The arterial supply of the pancreas is formed from several sources (Figure 2). The head and neck are supplied by the superior and inferior pancreaticoduodenal arteries. The superior pancreaticoduodenal artery is a branch of the gastroduodenal artery, which in turn is a branch of the common hepatic artery from the coeliac axis. The inferior pancreaticoduodenal artery is a branch of the superior mesenteric artery. Each pancreaticoduodenal artery has anterior and posterior branches which form arcades around the pancreas. These arcades run between the head of the pancreas and the medial curve of the duodenum, giving blood supply to both. As each arcade has contributions from both superior and inferior pancreaticoduodenal arteries, they also represent anastomoses between the coeliac and superior mesenteric arteries.

The body and tail of the pancreas are supplied by multiple branches of the splenic artery, which is a terminal branch of the coeliac axis, and gives off pancreatic branches as it travels superiorly over the pancreas towards the splenic hilum.

Venous drainage of the pancreas terminates into the portal system. Like its arterial supply, the body and tail of the pancreas drain via multiple tributary veins into the splenic vein, which runs along the posterior surface of the pancreas. The head and neck drain into the superior pancreaticoduodenal vein, which drains directly into the portal vein, and the inferior pancreaticoduodenal vein, which drains into the superior mesenteric vein.

The lymphatic vessels draining the pancreas follow the arterial system, emptying into the pancreaticosplenic and pyloric nodes, which drain into the superior mesenteric and coeliac lymph nodes.

Embryological development

The development of the pancreas begins around week four of gestation (Figure 3). The pancreas begins as dorsal and ventral

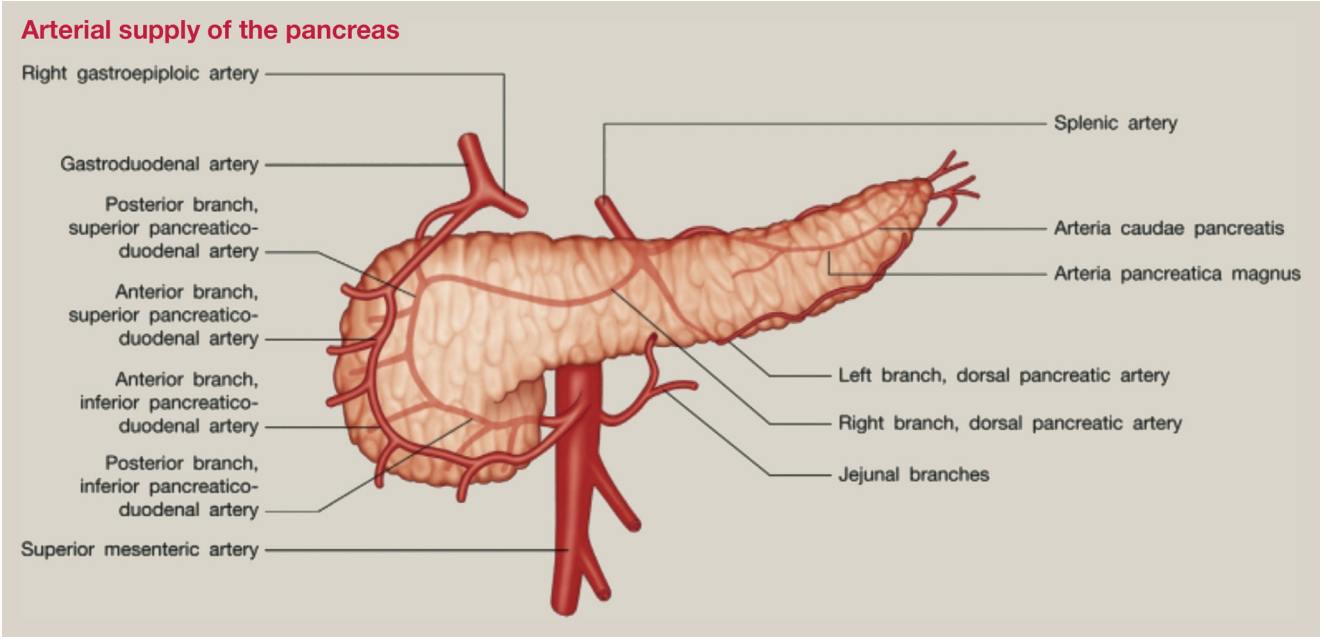

Figure 2

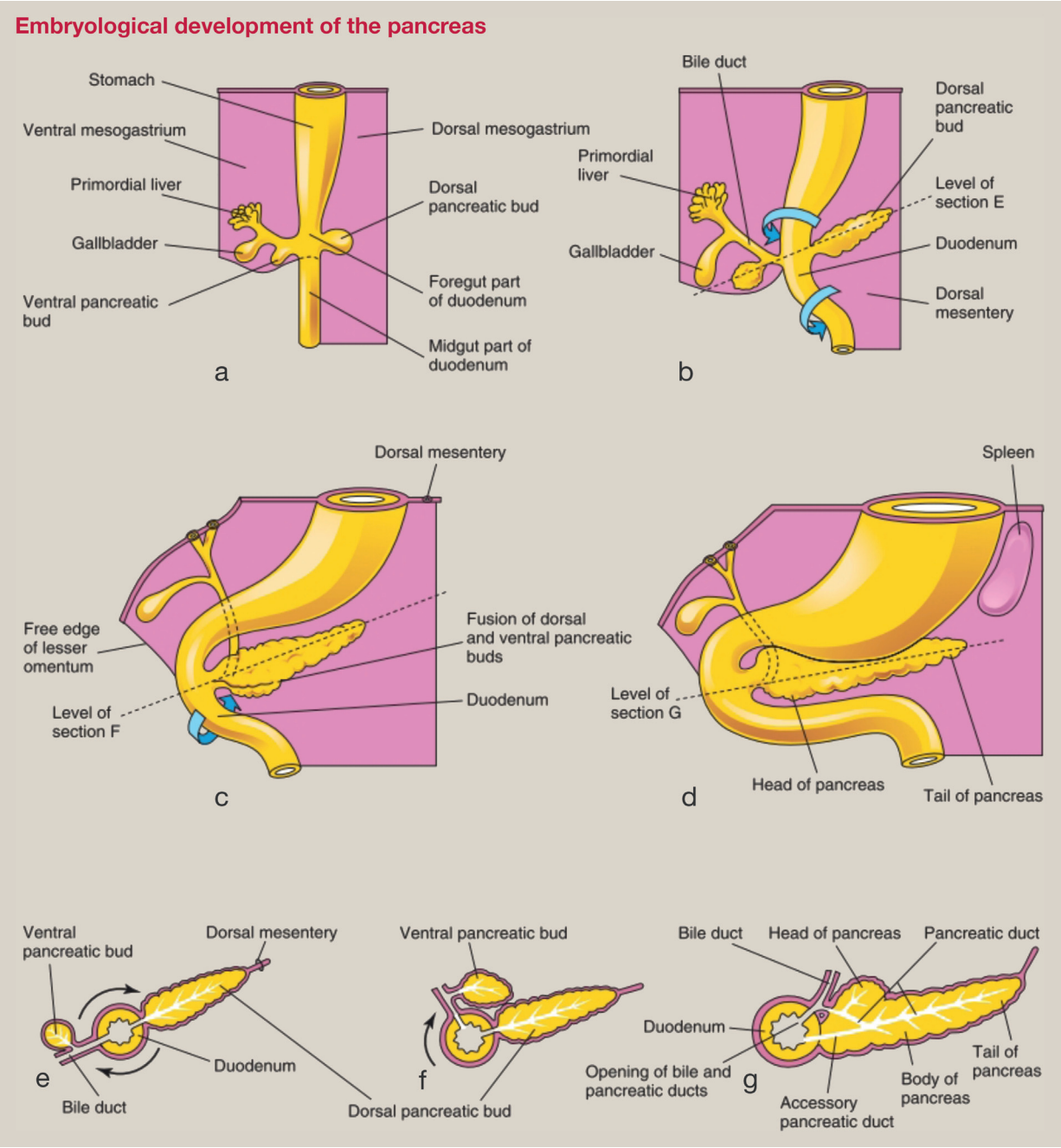

Figure 3

buds arising from the posterior foregut endoderm, which later develops into the duodenum. The ventral bud accounts for the development of the pancreatic head and uncinate process. As the duodenum develops, the subsequent rotation moves the ventral bud to a posterior and inferior position in relation to the dorsal bud. The ventral bud then fuses with the larger dorsal bud around week seven of gestation, which makes up the remainder of the pancreas. During development and fusion of the dorsal and ventral buds, the pancreatic ductal system also forms. The entirety of the ventral pancreatic duct, along with the distal portion of the dorsal pancreatic duct, give rise to the main pancreatic duct of Wirsung. The remaining proximal dorsal pancreatic duct forms the accessory pancreatic duct of Santorini.

Practice point 1: Management of Acute Pancreatitis

- Acute pancreatitis (AP) refers to the inflammation of the pancreas, typically characterized by epigastric pain and vomiting. It may range in severity from a mild, self-limiting illness with minimal or even an absence of radiological changes, to severe systemic inflammation with pancreatic necrosis, multi-organ failure, and even mortality
- The most common causes of AP are gallstones and ethanol. Many AP cases are also deemed to be idiopathic. However, it is thought that microlithiasis accounts for 80% of idiopathic pancreatitis. An elevated alanine aminotransferase (ALT) at presentation is highly indicative of gallstone aetiology

- AP is diagnosed when at least two of the following are present; symptoms typical of AP, elevated amylase/lipase over three times the normal limit, and radiological changes. For assessment of severity, early and serial measurements of C-reactive protein (CRP) and the presence of systemic inflammatory response syndrome (SIRS), particularly within the first 48 hours of presentation, are the best indicators
- The main focus of AP management is symptom control. The use of prophylactic antibiotics has not been shown to reduce mortality. However high dependency units should be considered for patients with a Modified Glasgow score >3, APACHE score >8, or a Ranson score >3
- AP, especially severe inflammatory cases, can cause a range of complications, including pancreatic necrosis, splenic pseudoaneurysm, and intra-abdominal collections. There are four kinds of intra-abdominal fluid collections that can be categorized based on timing, content, and the presence of a well-defined wall. These include:

    1. Acute peri-pancreatic collection: <4 weeks, no wall, fluid density
    2. Acute necrotic collection: <4 weeks, no wall, heterogeneous
    3. Pseudocyst: >4 weeks, defined wall, fluid density
    4. Walled off necrosis: >4 weeks, well defined wall, heterogeneous

- It is preferable to drain collections endoscopically using a large bore lumen-apposing metal stent (LAMS), through which collection can be washed out
- Necrosectomies are rare and if performed should be done through referral to a regional hepatobiliary unit. Endoscopic and percutaneous necrosectomies are associated with better outcomes

Practice point 2: Management of Pancreatic Adenocarcinoma

- Ductal adenocarcinoma accounts for >85% of all pancreatic neoplasms. Risk factors for pancreatic cancer include age, smoking, alcohol, family history, type 2 diabetes mellitus, chronic pancreatitis, and familial genetic conditions
- Surgery remains the only curative management for pancreatic cancer, due to the aggressive and indolent nature of the disease. Only 10%–15% of newly diagnosed patients are surgically resectable. Management for pancreatic cancer should always be discussed at a multidisciplinary team setting
- In patients selected for neoadjuvant chemotherapy, histology can be confirmed via fine needle aspiration (FNA) using endoscopic ultrasound, ERCP, or percutaneous CT guidance
- Resectability depends on the assessment of the vascular involvement of the portal vein, superior mesenteric artery (SMA) and superior mesenteric vein (SMV). The relations of the tumour to the first jejunal branch of the SMV is critical. If the SMV is involved by the tumour, reconstruction of the vessel is very unlikely
- The Whipple procedure is the classical operation and involves the en bloc resection of the pancreatic head, duodenum, common bile duct, distal stomach, and lymph nodes

The spleen

Anatomy and relations

The spleen is located within the left upper quadrant of the abdomen and is the largest lymphoid organ in the body. It has a slightly irregular and elongated wedge appearance and, due to its dense vascularization, has a deep purple appearance. The spleen functions to produce white blood cells, aid in antibody synthesis, filter and store blood, and remove inadequate red blood cells. Microscopically the parenchyma of the spleen is termed ‘pulp’ and can be separated into white and red pulp. White pulp forms the lymphoid tissue of the spleen and is involved in the production and maturity of white blood cells and production of antibodies. The red pulp is made up of splenic sinusoids and is involved in filtering blood to remove damaged red blood cells, as well as the storage of healthy red cells which can be released for inflammation regulation or compensation during haemorrhage. It also contains phagocytes and therefore has a role in destruction of microorganisms in an immune response.

The spleen can be divided into a superior and inferior pole, a visceral and diaphragmatic surface, and superior, inferior, and intermediate borders. The diaphragmatic surface is in contact with the adjacent diaphragm, which causes a convex shape, and has impressions from the left 9th to 11th ribs. The visceral surface has three areas of impressions from the adjacent organs, a colic area from the splenic flexure inferiorly, a gastric area from the stomach anteromedially, and a renal area for the left kidney posteromedially (Figure 4). The spleen is covered by a thin fibrous capsule, which can expand with the spleen. The entire spleen is also covered in peritoneum, except for the hilum. At the hilum, the peritoneal reflections form two important ligaments. The first is the gastrosplenic ligament, which connects the hilum to the greater curvature of the stomach and contains the short gastric vessels and left gastroepiploic vessels. The second is the splenorenal ligament, attaching the spleen to the left kidney, and contains the pancreatic tail and splenic vessels.

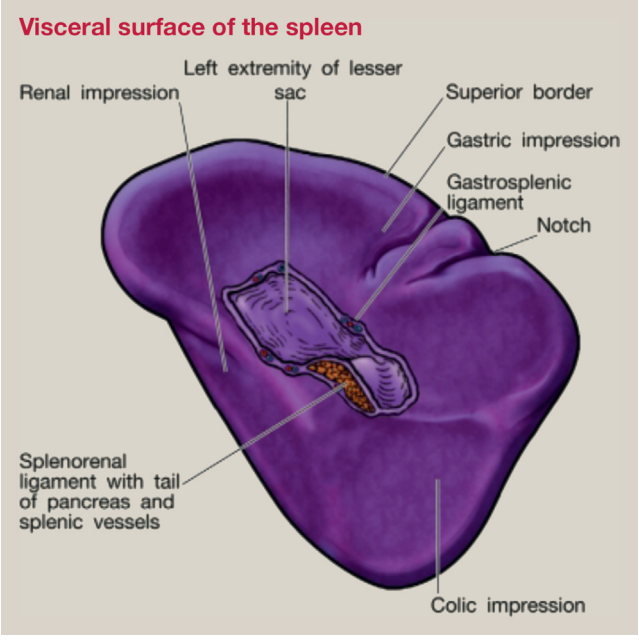

Figure 4

Blood supply and lymphatic drainage

The splenic artery branches from the coeliac axis, which in turn is a branch of the abdominal aorta at the vertebral level of T12. It travels to the spleen within the splenorenal ligament, running along the superior border of the pancreas and often following a very tortuous route. Upon entering the spleen, the splenic artery divides into superior and inferior branches, supplying the superior and inferior poles of the spleen. These branches then further divide into terminal segmental branches, the number of which is variable and determined by the number of splenic segments.

The venous drainage, like the arterial supply, also varies depending on the number of segments and venous tributaries. These venous tributaries emerge at the splenic hilum and unite to form the splenic vein within the splenorenal ligament. Along its course away from the spleen, the splenic vein receives tributaries from the short gastric veins, left gastroepiploic veins, pancreatic veins, and inferior mesenteric vein. It then merges with the superior mesenteric vein posterior to the neck of the pancreas to form the portal vein.

The lymphatics for the spleen drain into lymph nodes found at the splenic hilum and to retropancreatic nodes which in turn drain into the pre-aortic coeliac lymph nodes.

Embryological development

The spleen is derived from mesenchymal cells within the left leaf of the dorsal mesogastrium around week five of gestation. During development, the rotation of the stomach pushes these cells to the left upper quadrant, resulting in the location of the spleen. This rotation also forms the two double-layered peritoneal folds which become the gastrosplenic and splenorenal ligaments.

The cells needed for the spleen's haemopoietic function arise from the yolk sac wall and begin functioning in the generation of white and red blood cells within the second trimester. ◆

Practice point 3: Splenectomy

- Indications for splenectomy include trauma, haematological conditions (e.g. immune thrombocytopenia purpura), neoplasia (e.g. Hodgkin's lymphoma), and infection (e.g. hydatid disease). However, splenectomy due to trauma is seldom performed now due to greater access to interventional radiology and embolization of the splenic artery
- Partial splenectomy is also an option, especially in children under five or in adults with benign tumours (e.g. haemangioma, epidermoidal cysts) and haematological conditions causing hypersplenism
- The spleen triggers the immune response to encapsulated bacteria. As a result, patients undergoing splenectomy should be vaccinated against *Haemophilus influenza B, Streptococcus pneumonia,* and *Neisseria meningitidis* perioperatively
- Vaccination helps to reduce the chances of overwhelming post-splenectomy infection (OPSI), which is the most serious complication after splenectomy