

Describe the development of the pancreas, including developmental anomalies. What are its anatomical relations? With reference to these, how may pancreatic cancer present?

Introduction

The pancreas is an elongated, accessory digestive gland which lies retroperitoneally and transversely across the posterior abdominal wall, posterior to the stomach between the stomach on the right and the spleen on the left – largely in the transpyloric plane. The transverse mesocolon attaches to its anterior margin. The pancreas is both an endocrine and an exocrine gland. Its exocrine secretion, from acinar cells, known as pancreatic juice contains a number of digestive enzymes and is alkaline to neutralise the acidic chyme. The juice enters the duodenum via the main and accessory pancreatic ducts. It also secretes hormones from its endocrine parts, known as the islets of Langerhans. The hormones secreted are insulin and glucagons, which are responsible for maintaining blood glucose homeostasis.

Development of the pancreas

The pancreas develops between the layers of mesentery from the dorsal and ventral pancreatic buds of endodermal cells that arise in the caudal part of the foregut that is developing into proximal duodenum. The dorsal pancreatic bud is in the dorsal mesentery which attaches the developing gut tube to the posterior abdominal wall. The dorsal pancreatic bud is larger than the ventral, and appears first. It grows rapidly between the peritoneal layers of the dorsal mesentery. The ventral pancreatic bud grows between the layers of the ventral mesentery which attaches the developing gut tube to the anterior abdominal wall. It is in close proximity to the gall bladder which develops from a diverticulum from the hepatic duct. As the duodenum rotates to the right and becomes C-shaped, the ventral pancreatic bud is carried dorsally in a manner similar to the displacement of the entrance of the bile duct. The ventral pancreatic duct comes to lie posterior and inferior to the dorsal pancreatic bud. Later the parenchyma and the duct systems of the dorsal and ventral pancreatic buds fuse. (The parenchyma of the pancreas is derived from the endoderm of the pancreatic buds) As the pancreatic buds fuse, their ducts anastomose. The ventral pancreatic duct forms the uncinate process and the inferior part of the head of the pancreas. The remaining part of the gland is derived from the dorsal pancreatic bud. As the stomach, duodenum, and ventral mesentery rotate, the pancreas comes to lie along the dorsal abdominal wall. The main pancreatic duct (of Wirsung) forms from the entire duct of the ventral bud and the distal part of the duct of the dorsal bud. The proximal duct of the dorsal bud may persist as the accessory pancreatic duct (of Santorini). The main pancreatic duct and the bile duct enter the duodenum at the site of the major papilla. When present, the site of the accessory duct is at the site of the minor papilla. The pancreas ends up retroperitoneally. The peritoneum of the pancreas fuses with the peritoneum of the posterior body wall to become retroperitoneal. The pancreas is pushed up against the posterior body wall by the transverse colon.

In the third month of fetal life pancreatic islets of Langerhans develop from the parenchymatous tissue and scatter throughout the pancreas. This forms the endocrine portions of the pancreas. Insulin secretion begins at approximately the fifth month of

fetal life. Glucagon and somatostatin secreting cells also develop from the parenchymal cells.

There are some developmental anomalies of the pancreas. In about 10% of people, the duct system of the ventral and dorsal buds fails to fuse. This results in the original double system persisting and there are therefore two major outflows of the pancreas into the duodenum, rather than the single main pancreatic duct of Wirsung.

The ventral pancreatic bud consists of two components that normally fuse and rotate around the duodenum so that they come to lie posteriorly and inferiorly to the dorsal pancreatic bud. Occasionally however, the right portion of the ventral bud migrates along its normal route but the left migrates in the opposite direction. By these means the duodenum becomes surrounded by pancreatic tissue. Since it forms a 'ring like structure' around the duodenum it is known as an annular pancreas. This malformation of the pancreas can sometimes lead to complete duodenal obstruction due to the constriction that results from having the pancreas form in this way.

Another developmental anomaly is the presence of accessory pancreatic tissue. This accessory tissue shows all the histological properties of the pancreas itself, and may contain islet cells that have the ability to secrete insulin and glucagon. Such accessory pancreatic tissue can be found anywhere from the distal end of the oesophagus to the tip of the primary intestinal loop. It is most frequently found in the mucosa of the stomach and in Meckels diverticulum (found in about 2% of the population).

Anatomical relations of the pancreas

The pancreas can be divided anatomically into four parts: the head, body, neck and tail.

The head of the pancreas is the most dilated part of the organ. It is surrounded by the C-shaped curve of the duodenum, and lies to the right of the superior mesenteric artery which emerges from the aorta at the level L1 – to supply the midgut up to two thirds of the transverse colon. The head is firmly attached to the medial aspect of the descending and horizontal parts of the duodenum. From the inferior part of the head of the pancreas can be found a projection known as the uncinata process. It extends medially to the left. It lies posteriorly to the superior mesenteric artery (that is to say that the superior mesenteric vessels are trapped between the uncinata and the main pancreas. The head of the pancreas lies posteriorly on the inferior vena cava, the right renal artery and vein and the left renal vein. The bile duct passes inferiorly to enter the descending part of the duodenum. On passing posteriorly to the head of the pancreas it can either lie in a groove on the posterosuperior surface, or can be embedded in its substance.

The neck of the pancreas is only 1.5 – 2 cm long. It lies anterior to the superior mesenteric vessels, which groove its posterior aspect. The anterior surface of the pancreas is covered by peritoneum since the organ is retroperitoneal. However the anterior surface of the neck of the pancreas is adjacent to the pylorus – the inferior region of the stomach. An important relation posterior to the neck of the pancreas is the formation of the hepatic portal vein by the joining of the splenic vein and the superior mesenteric vein.

The longest part of the pancreas is the body. The body extends from the neck and passes to the tail. It lies to the left of the superior mesenteric vessels, passing over the L2 vertebra. The anterior surface of the body is covered with peritoneum and lies posteriorly to the omental bursa, also forming part of the stomach bed. Since the pancreas is retroperitoneal, this means that its posterior aspect is not covered with peritoneum. Thus it is in direct contact with the structures that lie posteriorly, which are: the descending abdominal aorta, superior mesenteric artery, left suprarenal gland, left kidney and associated renal vessels.

The final of the four anatomical parts of the pancreas is the tail. The tail lies anterior to the left kidney, where it is closely related to the hilum of the spleen and the left colic flexure. The tail is a relatively mobile appendage which passes between the layers of the splenorenal ligament with the splenic vessels. The tip of the tail does not usually end as a point, but ends bluntly, turned superiorly.

The final point to discuss is the positioning of the pancreatic ducts. The main pancreatic duct begins in the tail, running through the gland to the head, where it turns inferiorly and is closely related to the bile duct. The main pancreatic duct and bile duct fuse to form a short dilated hepatopancreatic ampulla, which opens into the descending duodenum at the major papilla. There are smooth muscular sphincters around each of the ducts. That around the hepatopancreatic ampulla is known as the sphincter of Oddi. These sphincters control the flow of bile and pancreatic juice into the duodenum. The uncinata process and inferior part of the head of the pancreas is drained by the accessory pancreatic duct which opens at the minor papilla. There is usually communication between the two pancreatic ducts.

Before leaving the anatomical relations it is necessary to briefly discuss the blood and nerve supplies to the pancreas. The pancreatic arteries mainly derive from the tortuous

splenic artery, which form several arcades with the gastroduodenal and superior mesenteric arteries. The body and tail of the pancreas are supplied by up to ten branches of the splenic artery. The head of the pancreas is supplied by the anterior and posterior superior pancreaticoduodenal arteries (branches of the gastroduodenal artery from the celiac trunk), and the anterior and posterior inferior pancreaticoduodenal arteries (branches of the superior mesenteric artery). The corresponding veins are tributaries of the splenic and superior mesenteric veins, eventually draining into the hepatic portal vein. The pancreas is supplied by autonomic nerves. Parasympathetic supply is via the vagus nerves. The sympathetic supply is via the thoracic splanchnic nerves which pass through the crura of the diaphragm. The nerve fibres reach the pancreas by passing along the arteries from the celiac plexus and superior mesenteric plexus.

Pancreatic Cancer

Pancreatic cancer is a very common cancer, but it is very difficult to treat. Signs and symptoms of pancreatic cancer often don't occur until the disease is advanced. The symptoms can all be explained by considering the relations of the pancreas. Such presentations of the disease include:

Upper abdominal pain that may radiate to middle or upper back. A tumour of the pancreas can put pressure on surrounding organs and nerves. Pain may be constant or intermittent and is often worse after eating or when lying down. The pain is referred to the midline by the sympathetics. Because many conditions other than cancer can cause abdominal pain, it's important to consider this as a possibility.

Unintended weight loss is common in pancreatic cancer. Weight loss occurs in most types of cancer because malignant cells deprive healthy cells of nutrients. But the problem is compounded in pancreatic cancer, which often affects the ability to digest and absorb what is eaten by affecting the production of pancreatic digestive enzymes, vitally important in the digestion of nutrients required by the body.

Half of all people with pancreatic cancer develop jaundice, which occurs when high levels of bilirubin, a breakdown product of worn-out blood cells, accumulate in the blood. Normally, bilirubin is eliminated in bile, a fluid produced in your liver. But if a pancreatic tumour blocks the flow of bile, excess pigment from bilirubin may turn the patient's skin and the whites of their eyes yellow as well as resulting in the enlargement of the gall bladder. In addition, urine may be dark brown and faeces white or clay-coloured due to the normal presence of bilirubin products in the faeces being responsible for the brown colouration. Although jaundice is a common symptom of pancreatic cancer, it's more likely to result from other conditions, such as gallstones or hepatitis. Jaundice caused by pancreatic tumours resulting in extrahepatic obstruction of the biliary system is known as obstructive jaundice.

In advanced cases of pancreatic cancer, the tumour may block a portion of the gastrointestinal tract in close proximity to the pancreas, causing nausea and vomiting.

Pancreatic cancer can affect the metabolism of sugar. In some cases, it may lead to diabetes — a serious disease that causes unusually high levels of sugar in the blood. This can occur because the pancreas produces two hormones that help regulate blood sugar levels homeostatically: insulin, which helps lower blood sugar, and glucagon, which raises blood sugar during fasting. In some cases, cancer may stimulate the pancreas to produce too much of these hormones. In others, when a great deal of tissue has been destroyed, the pancreas may not be able to produce any hormones.

Pancreatic tumour can also result in the obstruction of the hepatic portal vein or the inferior vena cava, if the tumour is present in the neck and/or body of the pancreas which lie anteriorly to these structures. This may affect blood flow to the lower parts of the body, possibly causing ischemia depending on the extent of the obstruction.