

INTRODUCTION

Acute pancreatitis (AP) is an inflammatory disease of the pancreas. It has a mild, self-limiting course in 80% of patients who recover without complications. The remaining patients have a severe disease with local and systemic complications, and this disease carries a mortality risk of 10-24% (Mao and Qiu, 2012). The treatment of mild AP is conservative and supportive, but severe episodes may require minimally invasive techniques or even surgical intervention. Thus, the accurate classification of the severity of AP is crucial. Key steps are to define its severity, to monitor the course of the disease, and to make informed clinical decisions (Wang et al., 2009).

The incidence of acute pancreatitis varies between 4.8 to 24.2 cases per 100,000 population, according to data from England, Denmark, and the United States. Death may occur in as many as 10% of patients (Banks et al., 2010). The incidence of chronic pancreatitis has not been well studied. Most estimates are based on studies from the 1980s and 1990s performed throughout European countries (Spanier et al., 2008).

Nearly 80% of cases of AP worldwide are caused by gallstone obstruction and high alcohol intake. Other causes like hypertriglyceridemia and drugs account for the rest. It is necessary to identify the etiology to institute definitive management and prevent further attacks (Greenberger and Toskes, 2005).

Many reports from different centers in the Gulf region revealed gallstones to be the predominant cause as it is responsible about 42% of pancreatitis cases patients (Singal et al., 2003). Another major cause was idiopathic origin (38.5%). The incidence of pancreatitis due to hypertriglyceridemia formed about 1.3 to 3.8% (Abu-Eashy, 2001). Alcohol consumption is one of the causes of pancreatitis but is significantly low in Saudi Arabia. While in Western countries alcohol is the second

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most common cause of acute pancreatitis and the commonest cause of recurrent pancreatitis (Matar, 2006).

Radiological imaging is an important component in the evaluation of pancreatic disease. CT has been the initial imaging modality of choice for evaluating pancreatic pathology. The advantages of IV contrast-enhanced CT imaging in staging acute pancreatitis is based on its capacity to directly assess the severity of an acute attack, the involvement of the retroperitoneal peripancreatic tissues and its particular ability to diagnose and quantify pancreatic necrosis (Balthazar, 2002).

Recent improvements in multi-detector CT (MDCT) technology during the past decade, with fast image acquisition and improved spatial resolution, have increased the accuracy of CT for characterization in the pancreas, diagnosing disease severity and its possible complications (Soto 2005). This has allowed CT to remain the gold standard for the evaluation of pancreatic pathology despite the advent of other imaging modalities, including MRI, PET and endoscopic ultrasound (Chu et al., 2012).

The aim of our study was to highlight the importance of early diagnosis of acute pancreatitis in management and the role of multi-slice CT in diagnosis of acute pancreatitis and classification that help for early and accurate management.

AIM OF THE WORK

The aim of this work is to evaluate the diagnostic role of multi-detector computed tomography (MDCT) in diagnosing inflammatory pancreatic diseases and the related complications.

EMBRYOLOGY OF THE PANCREAS

The pancreas makes its appearance in the fetal embryo as early as the 4th week of gestation. The development of pancreas starts as dorsal and ventral outpouchings from the endodermal lining of the primitive duodenum (Figure I) (Kamath et al., 2006).

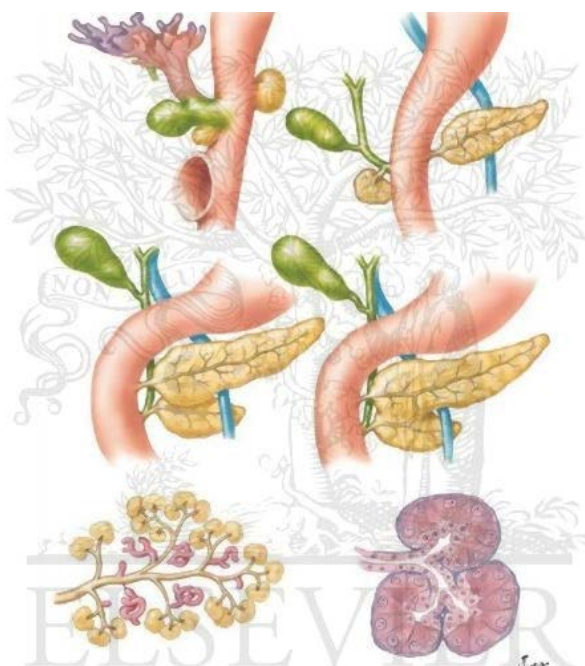


Figure I. Embryology of the pancreas (Kamath et al., 2006).

The dorsal bud appears earlier than the ventral bud. The former eventually forms the neck, body, tail, and superior part of the head of the pancreas later on. The ventral bud appears more caudally and is closely related to the bile duct and hepatic diverticulum and develops into the inferior part of the head and uncinate process of the pancreas. The two parts of the pancreas are brought into apposition by the partial rotation of the duodenum by 7 weeks of gestation, and they eventually fuse together by 8 weeks. Each part of the primitive pancreas has an axial duct. The dorsal duct (duct of Santorini) arises directly from the duodenal wall and the ventral duct (duct of

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Wirsung) arising from the common bile duct (Miller, 2002). At the time of the fusion of the dorsal and ventral parts of the pancreas, the ducts fuse at the junction of the head and body of the pancreas to form the main pancreatic duct (figure II) (Kamath et al., 2006). A wide variety of anatomic variations exist in relation to the fusion and openings of the dorsal and ventral ducts (Meyers, 2000).

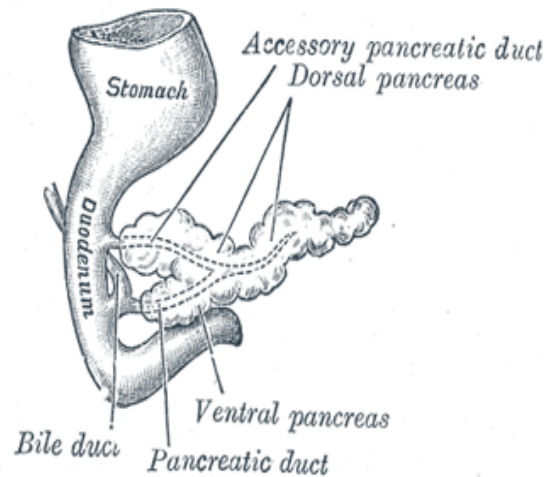


Figure II. Pancreas of a human embryo at end 8th week (Miller, 2002).

As the rotation of the foregut progresses, the dorsal mesoduodenum and the dorsal mesogastrium fuse with the parietal layer of the peritoneum to become the posterior wall of the lesser sac. The dorsal mesogastrium outpouches as a result and forms the omentum. The posterior leaf of this extension fuses with the mesentery of the midgut and develops into the transverse mesocolon over the pancreas (Figure III). This transition embeds the pancreas in the retroperitoneum, except for the most distal portion of the tail, which remains within the dorsal mesogastrium that becomes the splenorenal ligament carrying the splenic artery and vein to the spleen (Vikram et al., 2009).

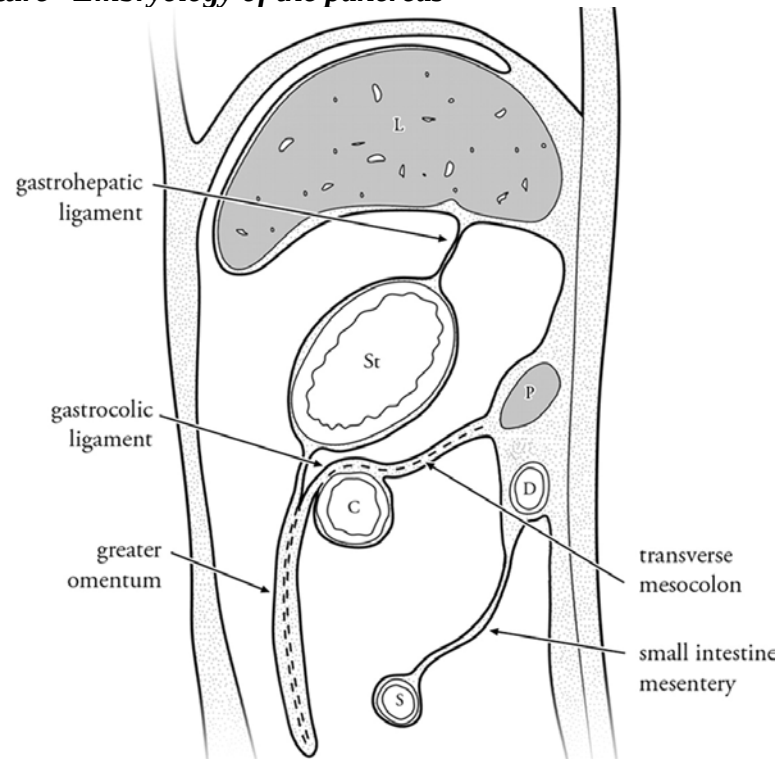


Figure III. The transverse mesocolon is formed by the fusion of the posterior leaf of the dorsal mesogastrium with the mesentery of the midgut. Hence, a direct contiguity is established between the transverse mesocolon and the greater omentum. C = colon. D= duodenum, P = pancreas, S = small intestine, St = stomach. (Vikram et al., 2009).

ANATOMY OF THE PANCREAS

PANCREAS AND ITS RELATED RETROPERITONEAL REFLECTIONS

The pancreas is considered the largest digestive gland and performs both exocrine and endocrine functions. It is Salmon pink in color with firm, lobulated smooth surface (Standring, 2005).

The pancreas is divided into the head, neck, body, and tail. The uncinate process is the inferior portion of the head of the pancreas. The head of the pancreas lies in the “C” loop of the duodenum. The posterior surface of the head is separated from the inferior vena cava only by retroperitoneal fat. The neck corresponds anatomically to that part of the pancreas lying anterior to the SMA and vein and the beginning of the portal vein. The tail of the pancreas extends toward the hilum of the spleen, and the distal tail lies in the splenorenal ligament. The distinction between the body and tail is poorly defined (Figure IV) (Temel et al., 2012).

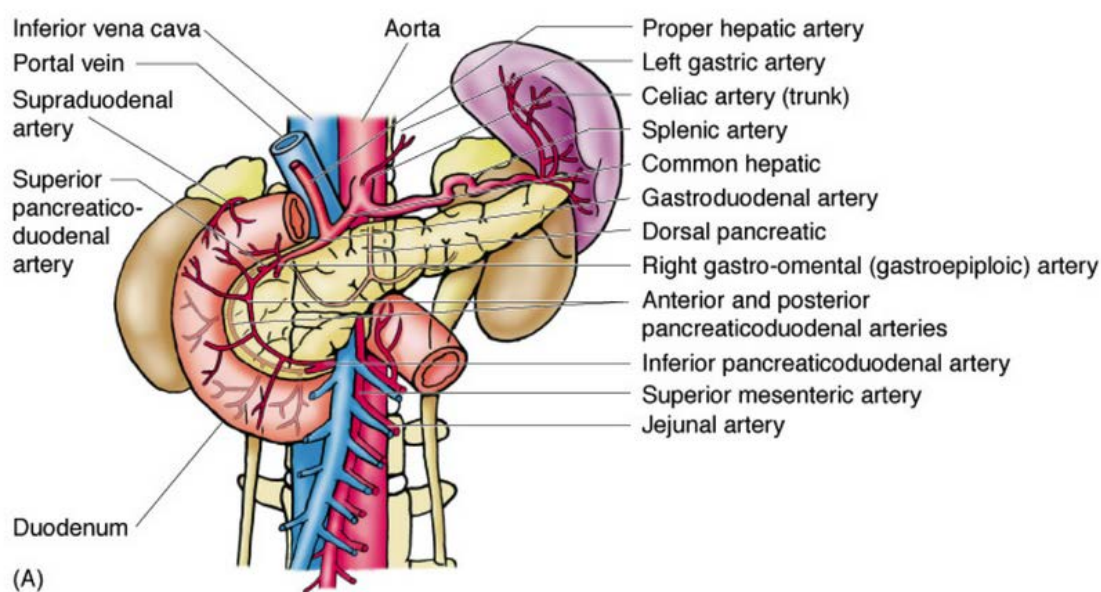


Figure IV. Gross anatomy of the pancreas and its relationships (lippincott Williams & Wilkins).

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The head of the pancreas connects to the liver and the lesser curvature of the stomach via the hepatoduodenal and gastrohepatic ligaments, which are derived from the ventral mesogastrium. The tail communicates with the hilum of the spleen and the greater curvature of the stomach via the splenorenal and gastrosplenic ligaments derived from the dorsal mesogastrium illustrated in figure V (Temel et al., 2012).

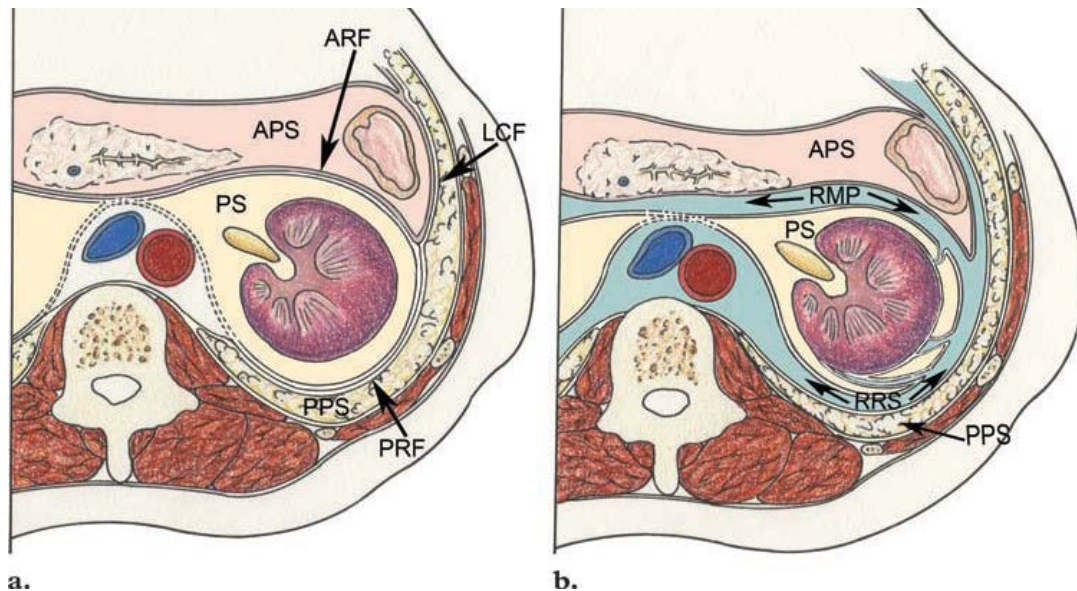


Figure V. Fascial planes and spaces of the retroperitoneum. **(a)** Drawing illustrates the traditional tricompartiment model of the retroperitoneum, which is accordingly divided into the anterior pararenal space (*APS*), perirenal space (*PS*), and posterior pararenal space (*PPS*). The anterior renal fascia (*ARF*), posterior renal fascia (*PRF*), and lateroconal fascia (*LCF*) divide the spaces. **(b)** Drawing illustrates the recently modified tricompartiment model, which reflects the understanding that the perirenal fascia is laminar and variably fused and there are interfascial connections between the spaces. The retromesenteric plane (*RMP*), retrorenal space (*RRS*), and lateroconal space are potential interfascial communications. Perinephric septa run between the renal capsule and the perinephric fascia, allowing subcapsular fluid to communicate with the retrorenal space or retromesenteric plane. *APS* = anterior pararenal space, *PPS* = posterior pararenal space, *PS* = perirenal space (Scialpi et al., 2004).

PANCREATIC BLOOD SUPPLY

The arterial blood supply to the pancreas is derived from the branches of the celiac trunk and the superior mesenteric artery (SMA). The celiac trunk is located superior to the body of the pancreas, and the splenic artery courses along the superior margin of the pancreas. The SMA arises from the aorta posterior to the neck of pancreas at its origin and runs inferiorly, anterior to the uncinate process along with the superior mesenteric vein (SMV). The anterior and posterior superior pancreaticoduodenal branches of the gastroduodenal artery anastomose with the corresponding inferior pancreaticoduodenal branches of the SMA to form an arterial arcade around the head of the pancreas. The splenic vein runs along the posterior and superior aspects of the pancreas along with the splenic artery and forms an important landmark for the posterior surface of the pancreas (figure VI). The splenic vein joins the SMV behind the neck of the pancreas to form the portal vein (Shioyama et al., 2002).

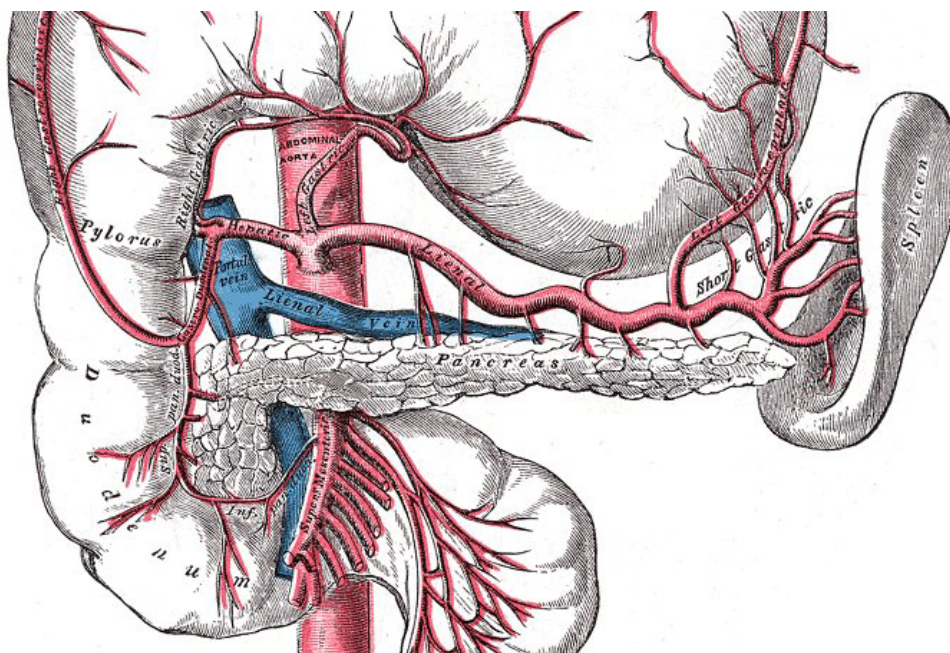


Figure VI. Pancreatic vascular supply originating as branches from the splenic artery (to the body and tail), Superior and inferior pancreaticoduodenal branches originating from the gastroduodenal and SMA respectively (Standring, 2005).

CT ANATOMY OF THE PANCREAS

The pancreas is a retroperitoneal organ that lies in the anterior pararenal space with an oblique orientation to the horizontal plane of approximately 20 degree with the tail located at higher position than the head. The shape, position, and orientation of the pancreas are variable depending on age, body habitus, and position of the spleen and left kidney (Balthazar, 1989). Generally, the head of the pancreas measures about 3–4 cm, body 2–3 cm, and tail, about 1–2 cm in the anteroposterior diameter with a gradual transition between segments. The pancreas is surrounded by peripancreatic retroperitoneal fat that delineates it on CT scan (Yu et al., 2004).

Several adjacent axial images are required to visualize the entire gland. The normal pancreas appears as a sharply defined, homogeneously enhancing structure, having a smooth contour or a slightly corrugated acinar configuration. The pancreatic head bears a constant relationship with the second part of the duodenum and the uncinate process with the third part of the duodenum. The neck and body of the pancreas are related anteriorly to the stomach, from which they are separated by the potential space of the lesser sac. Adequate distension of the stomach and duodenum with water is necessary to display this intricate relationship of the pancreas to bowel. The tail of the pancreas is intraperitoneal and is situated within the spleno-renal ligament. It is variable in position depending on the location of the spleen and left kidney. The transverse mesocolon is attached to the anterior surface of the pancreas, and the root of small bowel mesentery is inferior to the body of the pancreas (Balthazar, 2009).

Baseline CT attenuation values of the normal pancreas on non contrast administration are 40–50 Hounsfield Units (HU). Lower baseline measurements should be expected in patients with pancreatic fatty infiltration. A homogeneous enhancement of the entire pancreatic gland to 100–150 HU occurs during the

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administration of intravenous contrast (Figure VII). These measurements may show slight individual variations, usually not more than 10–20 HU between different segments of the pancreas. Small bulges or mild contour abnormalities should be considered variants to normal, as long as the gland maintains homogenous attenuation and uniform texture (Balthazar, 2009).

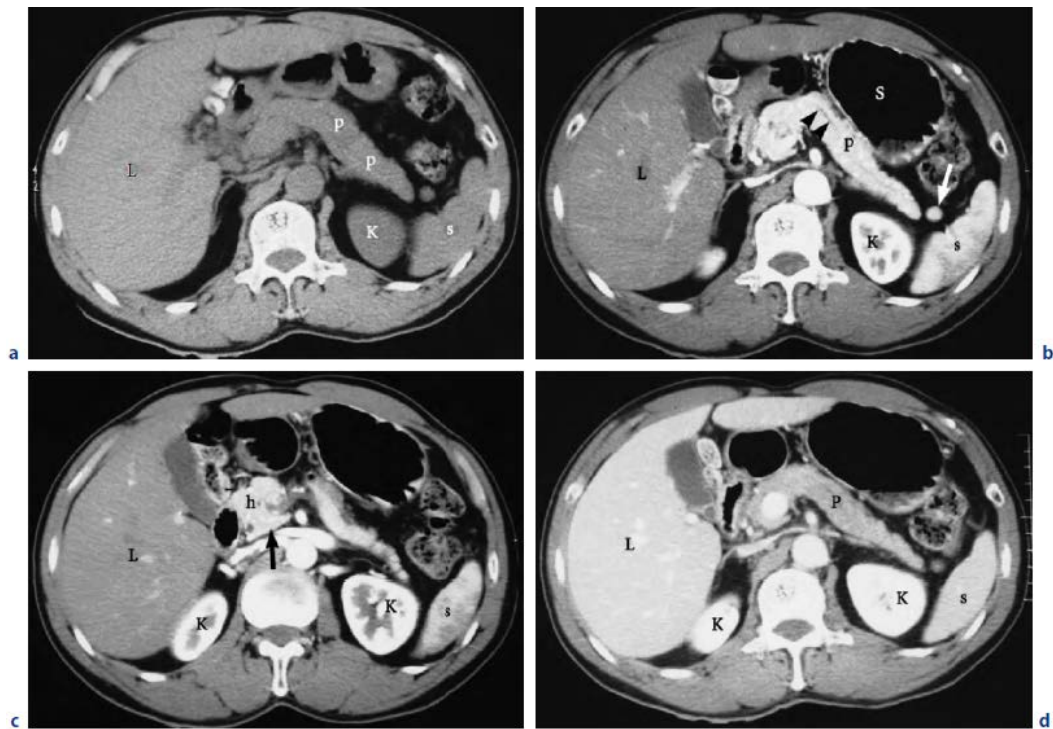


Figure VII a–d. Normal pancreas, three phase MDCT examination. a) Non-contrast phase. Pancreas (P) is visualized with a basic attenuation value of 50 HU similar to the spleen (s) and liver (L). K: kidney. b&c) Arterial phase. Homogeneous enhancement of the pancreas (160 HU) and visualization of a normal pancreatic duct (arrowheads). Head of pancreas (h) and uncinus process (black arrow) are seen. Small accessory spleen is present close to pancreatic tail (white arrow). S: stomach. d) Portal phase shows homogeneous enhancement (100 HU) of the pancreas, and normal peripancreatic structures (Balthazar, 2009).

PANCREATIC VASCULAR RELATIONSHIP

The celiac trunk is located superior to the body of the pancreas, and the splenic artery courses along the superior margin of the pancreas. The SMA arises from the aorta posterior to the neck of pancreas at its origin and runs inferiorly, anterior to the uncinus process along with the superior mesenteric vein (SMV). This important

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relationship of the superior mesenteric vessels with the pancreas is best displayed in sagittal MPR (Ross et al., 2000). The anterior and posterior superior pancreaticoduodenal branches of the gastroduodenal artery anastomose with the corresponding inferior pancreaticoduodenal branches of the SMA to form an arterial arcade around the head of the pancreas. The splenic vein runs along the posterior and superior aspects of the pancreas along with the splenic artery and forms an important landmark for the posterior surface of the pancreas. The splenic vein joins the SMV behind the neck of the pancreas to form the portal vein (Shioyama et al., 2002). Coronal oblique MIP and CPR demonstrate the peripancreatic vessels in the staging of pancreatic carcinoma (Figure VIII) (Crabo et al., 1999).

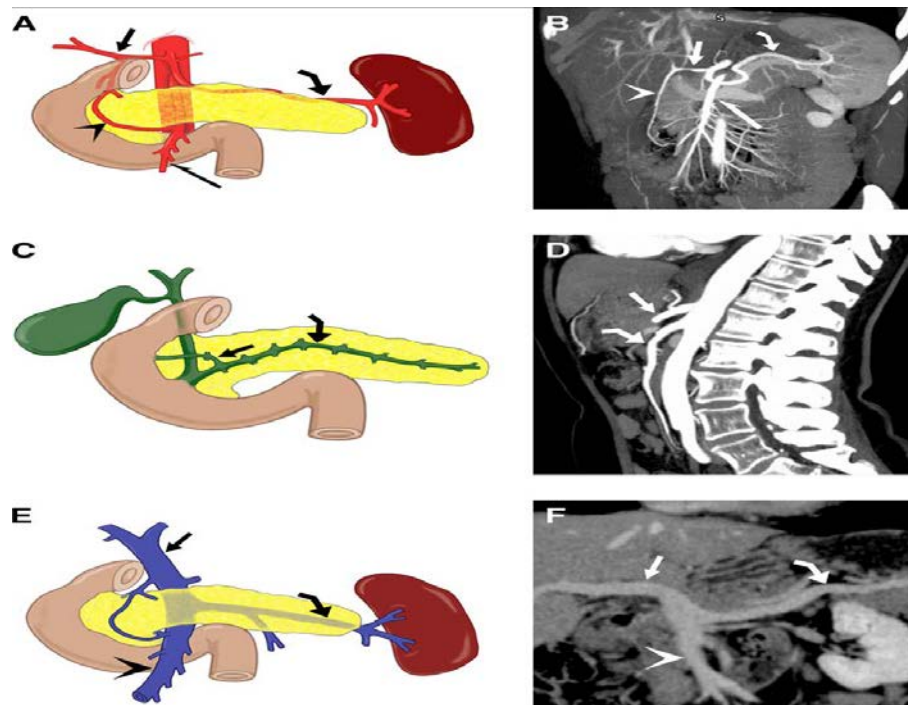


Figure VIII. Vascular and biliary relations. (A)Diagram of the peripancreatic arteries showing hepatic A. (arrow), splenic A. (curved arrow), SMA (half arrow), and gastroduodenal A. (arrowhead). (B) Coronal MIP CT image of the peripancreatic A. (C) Diagram demonstrating distal CBD, main pancreatic and accessory pancreatic duct (curved and straight arrows). (D) Sagittal MIP CT image showing celiac axis and SMA (straight and curved arrow). (E) Diagram showing main portal, splenic V. (straight and curved arrow), and SMV (arrowhead). (F) Coronal oblique MIP of the peripancreatic V. (Paspulati, 2005).

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Pancreatic and extra-hepatic bile duct

The distal common bile duct courses inferiorly through the dorsal aspect of the head of the pancreas to meet the main pancreatic duct at the ampulla of Vater. The main pancreatic duct courses along the long axis of the pancreas and joins the distal common bile duct to form the ampulla of Vater, which opens into the second part of the duodenum at the major papilla. The accessory pancreatic duct of Santorini opens into the duodenum at the minor papilla, which is situated proximal to the major papilla. The normal pancreatic duct measures 2 to 3 mm in diameter and may become wider in elderly individuals. Curved planer reconstruction (CPR) displays the entire course of the pancreatic duct in a single image (Figure IX) (Neri et al., 2004).

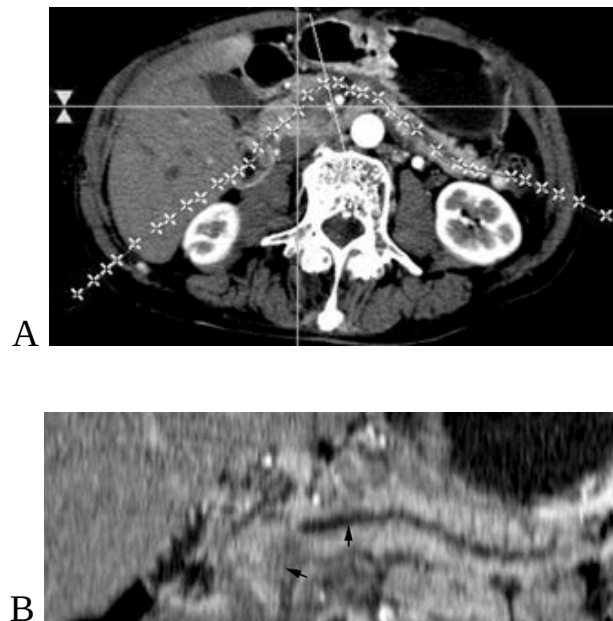


Figure IX . Curved planner reconstruction images. A) Showing how to construct the curved planner image. B. The curved reconstructed image showing the whole pancreatic duct in one plane with pancreatic head lesion (Gong and Xu 2004).

OTHER IMAGING MODALITIES OF THE PANCREAS

X-Ray:

Usually the normal pancreas could not be visualized in plain X-Ray. Only in severe emphysematous changes air at its anatomical site can be appreciated.

Ultrasound:

The normal pancreatic parenchyma echogenicity is similar to that of the liver (or slightly hypoechoic) provided it has homogeneous structure (Figure X). In obese or elderly patients, the pancreas can be normally hyperechoic due to fat load or fibrosis, respectively (Figure XI) (Şirli and Sporea, 2010).

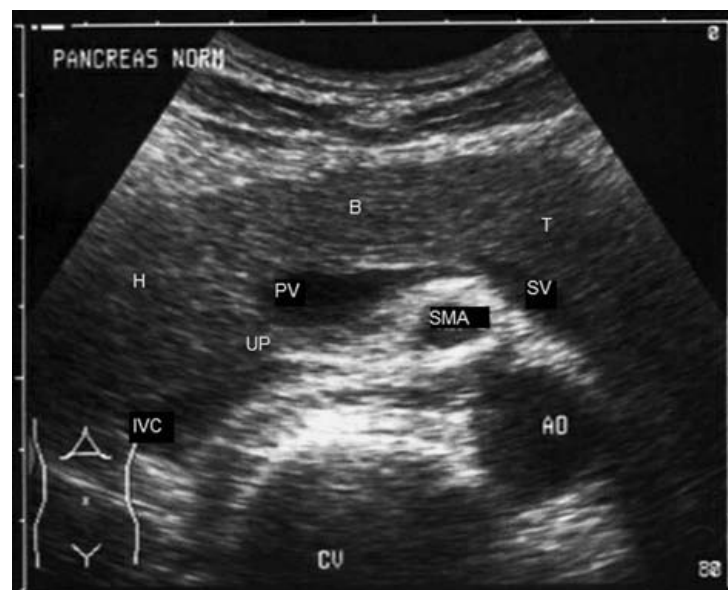


Figure X. Normal U/S of the pancreas: PV: portal vein; SV:splenic vein; AO:Aorta; IVC:inferior vena cava; H,B,T: head, body and tail of the pancreas; UP:uncinate process; CV:vertebra (Şirli and Sporea, 2010).

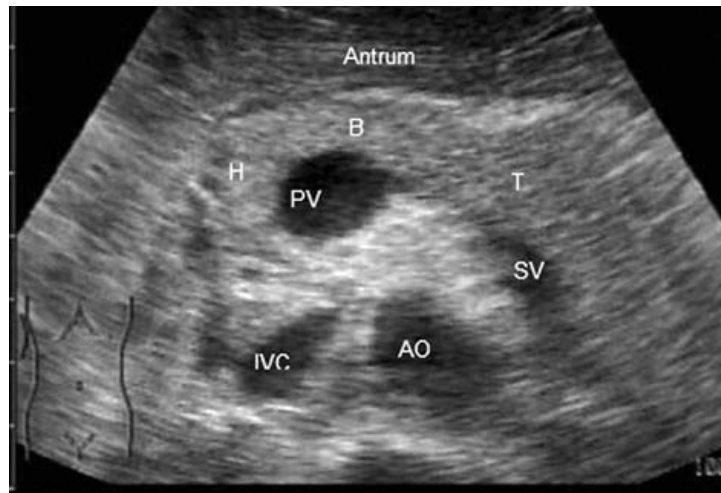


Figure XI. Normal U/S of the pancreas in an elderly patient (hyperechoic): PV: portal vein; SV: splenic vein; AO: Aorta; IVC: inferior vena cava; H, B, T – head, body and tail of the pancreas (Şirli and Sporea, 2010).

Magnetic resonance imaging (MRI) anatomy

Normal pancreatic parenchyma demonstrates high signal intensity compared to liver parenchyma on unenhanced T1-weighted fat suppressed sequences (Figure XII). This relative high signal on T1-weighted imaging is likely due to the presence of aqueous proteins in the acini of the pancreas. Normal pancreas is isointense or slightly hypointense to normal liver on T2-weighted sequences (Figure XIII). Following intravenous administration of a gadolinium chelate, the normal pancreas demonstrates homogenous enhancement with maximal enhancement during the pancreatic arterial phase becoming isointense to the liver on subsequent phases of imaging (Figure XIV) (Matos et al., 2002).