EFSUMB Course Book

Student Edition

Editors: Jan Tuma, Radu Badea, Christoph F. Dietrich

Ultrasound of the pancreas

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Introduction

Ultrasonography (US) is usually the first imaging modality for the primary evaluation of the pancreas. In fact, despite some well-known limitations, the pancreatic gland can almost always be adequately visualized by US, a non-invasive, relatively low cost, widely available and easy to perform imaging method. The conventional method is moreover implemented by Tissue harmonic imaging (THI) and Doppler imaging, which play an important role in the diagnosis and staging of pancreatic diseases. Then, contrast enhanced ultrasound (CEUS) represents a further advance in the characterization of both focal solid and cystic lesions, providing a real-time evaluation of macro and microcirculation.

Anatomy

The pancreas is a compound gland (both exocrine and endocrine) connected to the digestive system which empties its secretion into the lumen of the duodenum. It is a medium retroperitoneal organ, slightly flattened and tapered, located in the upper part of the abdomen, transversally in front of the main vessels, at the level of the first or second lumbar vertebra. It has to be considered a quite posterior fixed organ. The pancreas is prone to remarkable volume changes, depending on age, sex and kind of constitution. Its mean length is 16-20 cm, mean height 4-5 cm and thickness 2-3 cm. Generally the pancreas is larger in men than in women. Its weight varies between 30 and 100-150g. Its colour is white-grey, and it becomes flush during digestion, because of increased blood flow. In normal conditions it has a friable consistency, while it becomes very hard in chronic pancreatitis, in tumours and after radiotherapy, all these conditions characterized

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by a marked increase in the fibrous component. The pancreas is classically divided in four (or five) main portions: head, uncinate process, neck, body and tail. It grows quickly during the childhood and adolescence, reaching its maximum size around 40 years of age and it is generally larger in men than in women. The head is located on the right side, it lies within the curve of the duodenum and appears completely leaned against the posterior abdominal wall in contact with the inferior vena cava behind and the portal vein at the top. The uncinate process originates from the lower portion of the head, to which it belongs, and lies posteriorly to the superior mesenteric vessels. The neck or isthmus is the connection between head and body and generally appears as a slight constriction connecting the two parts. Its backside is related to the origin of the portal vein, formed by the junction of the superior mesenteric and splenic veins. The body is centrally placed, slightly flattened anteroposteriorly and more developed craniocaudally. It is the most superficial part of the pancreas, since it is pushed forward by the vertebral column. The tail is posteriorly orientated, left-upward, getting in touch with the splenic hilum as well as the left adrenal gland and upper kidney. It represents the mobile part of the gland, being partially surrounded by peritoneum. The veins of the pancreas open into the splenic and superior mesenteric veins. The superior mesenteric vein runs over the uncinate process, whereas the splenic vein, rising from the splenic hilum, courses along the supero-posterior surface of the pancreas. The arteries of the pancreas derive from the splenic and the pancreaticoduodenal branches of the hepatic and superior mesenteric arteries. The splenic artery, arising from the celiac artery, runs along the superior margin of the gland. In 92% of cases also the common hepatic artery, which courses along the superior margin of first portion of the duodenum and continues into the proper hepatic and gastroduodenal arteries, arises from the celiac artery. The gastroduodenal artery courses along the ventral surface of the pancreas. The superior mesenteric artery, arising from the aorta behind the lower portion of the pancreatic body, courses anteriorly to the uncinate process and the third portion of the duodenum. The pancreatic ductal system is represented by the main pancreatic duct (Wirsung's duct) and the accessory pancreatic duct (Santorini's duct). The main pancreatic duct originates from the junction of the small ducts of the tail lobules. It runs transversely from the left to the right to flow into the major duodenal papilla (of Vater) together with the common bile duct. It appears as a thin hypoechoic line bordered by two echogenic margins and its diameter varies from a maximum of 3 mm in young adults to 5 mm in the elderly. The accessory pancreatic duct (Santorini's duct) originates from the duct of Wirsung and crossing just the head of the pancreas, more superficially than the main duct, it flows into the minor duodenal papilla, located 2 cm higher than the major one.

Examination technique

The US examination of the pancreas is best performed on patients who have fasted overnight. The water technique, making the patient drink 250-500 ml of water, to improve the evaluation of the gland, is really not so useful, because of simultaneous ingestion of gas together with fill in to the stomach limiting the possibility of compression with probes. The examination generally begins with the patient in supine position, although changing position is often required to achieve the best visualization of the pancreas.

Ultrasound scans and pancreatic imaging

The anatomic features of the pancreas, its tilted and curved shape in all the three planes of space, represent a conditioning factor with regard to its imaging study.

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The study of the pancreas includes transverse, longitudinal and angled oblique scan planes [Figure 1]. For transverse scans, the left lobe of the liver can be used to start the examination as a first window into the pancreatic bed. Graded compression with the probe or deep inspiration may displace the superimposed viscera obstructing the visualization of the gland. Visualization of the abdominal aorta and vena cava means that an adequate compression is being employed. Sagittal scanning begins in the midline, where the great vessels are visualized, and proceeds until the right kidney, to the right, and the splenic hilum, to the left.

Figure 1 Pancreas. Ultrasound oblique scan of the pancreatic gland with visualization of the pancreatic tail, the body, the isthmus and the upper part of the head of the pancreas.

In normal conditions, the pancreas shows regular and homogeneous echogenicity, usually equal to or slightly greater than the liver. Anatomic landmarks should be identified in scans of the pancreas, in the following order: aorta, inferior vena cava, superior mesenteric artery, superior mesenteric vein, splenic vein, gastric wall and common bile duct.
In transverse craniocaudal planes, the left side of the pancreas appears before the right side, because of its higher position. It is identified by a plane passing through the emergency of the celiac trunk. The left portions of the gland can be partially covered by bowel gas. The plane passing through the splenic vein demonstrates the typical "comma" morphology, putting in evidence the body with the main pancreatic duct [Figure 2] and the isthmus of the pancreas on the confluence of the splenic with the superior mesenteric vein.

Figure 2 Wirsung's duct. Ultrasound oblique scan of the pancreatic body with visualization of the main pancreatic duct (arrow).

At the level of the lateral border of the head it is often possible to see the gastroduodenal artery ventrally, and the common bile duct dorsally. The scan passing through the mesenteric vessels visualizes the lower portion of the pancreatic head and the uncinate process, located between the superior mesenteric vein and the inferior vena cava. The superior mesenteric artery appears in front of the aorta, to the left of the superior mesenteric vein. Longitudinal scans are performed on all anatomic parts of the pancreas. The head is visualized in all its extension, in relationship with the inferior vena cava. Its cephalic portion is cranially delimited by the portal vein and the first duodenal part; more caudally it relates with the third duodenal portion. By a longitudinal and slightly oblique scan is usually possible to visualize the intra-pancreatic common bile duct [Figure 3].

Figure 3 Intrapancreatic common bile duct. Ultrasound longitudinal and slightly oblique scan of the pancreatic head with visualization of the Wirsung's duct and the intrapancreatic tract of the common bile duct (arrow).
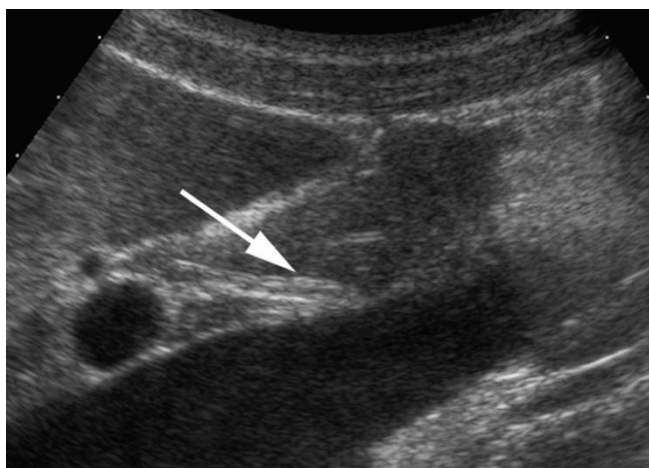
The scans at the neck level require the superior mesenteric vein as reference point, which is visualized at the junction with the splenic vein. Just more dorsally it is possible to recognize the uncinate process. The main pancreatic duct can be visualized at the level of the pancreatic body [Figure 2]. The reference point on the body is represented by the splenic vessels, transversally orientated, which course on the superior border. The tail can be visualized on a longitudinal anterior scan, even if the demonstration of this anatomic

structure is often difficult, owing to the gastric gas covering. The left intercostal scans are generally used to localize the caudal portion by using the splenic acoustic window.

Doppler study of the pancreas

Doppler imaging is a well-known technology that improves the conventional US examination, providing complementary information about the vascular structures. In particular, it provides useful anatomic information and an accurate evaluation of patency (colour power study) and blood flow (color-Doppler study). Its high sensitivity in evaluating flow in the peripancreatic vascular structures (the portal vein, the celiac trunk, the splenic artery and vein, the gastrodudenal artery, the superior mesenteric artery and vein, the aorta and the inferior vena cava), and in smaller intrapancreatic and intratumoral vessels, ensures to this technology an important role in diagnosing and staging pancreatic diseases. The same multifrequency curved array transducers (3-4 MHz) of conventional US is used. The frequency setting varies from 1 to 4 MHz, depending on the targeted vascular structures (lower frequencies for the main peripancreatic vessels and higher frequencies for smaller vessels). Colour-flow Doppler imaging, combining both anatomic and velocity data, provides qualitative and quantitative information to the conventional images as colour data: red represents blood moving toward the transducer, whereas blue represents blood moving away. Variation of the velocity is also reproduced as different color intensity: the lighter the colour is, the higher the velocity. Doppler and pulsed-Doppler appearance of peripancreatic vessels has been well documented. In normal conditions, the mean speed of blood in peripancreatic arteries is about 103 ± 18 cm/s in the celiac trunk, 78 ± 16 cm/s in the hepatic artery, 85 ± 18 cm/s in the splenic artery and 100 ± 22 cm/s in the superior mesenteric artery. Mean portal flow velocity is 12-20 cm/s. The resistance index in the superior mesenteric artery is in general higher than in the other arterial vessels.

Contrast enhanced Ultrasound

Contrast enhanced Ultrasound (CEUS) is a relatively recent implementation of conventional US which improves the characterization of both focal solid and cystic diseases of the pancreas. The administration of microbubbles allows an accurate evaluation of macro- and microcirculation, in and around a focal mass. The CEUS study should be performed after an accurate conventional US of the pancreas with the evidence of a focal or diffuse pancreatic disease. The examination requires the use of the same multifrequency curved array transducers used for conventional US. The contrast agents have a purely intravascular distribution (blood pool) without any interstitial phase, so differing from all contrast media used during CT and MRI examinations. In this way, only vascularized structures are visible after the administration of microbubbles.

Pancreatic diffuse inflammatory disease

Acute pancreatitis

Acute pancreatitis is a common acute inflammatory disease of the pancreas whose diagnosis is based on clinical and laboratory evaluation. Acute pancreatitis is classified as mild (interstitial oedema) [Figure 4] or severe (necrosis, fluid collections) [Figure 5]. The first one well responds to medical treatment, while severe pancreatitis is associated with organ failure and/or local complications such as necrosis, abscess or pseudocysts.

Figure 4 Mild acute pancreatitis. Ultrasound oblique scan of the pancreatic gland shows enlargement of the gland with the body appearing slightly hypoechoic in respect to the head.

Figure 5 Severe acute pancreatitis and pancreatic fluid collection. Ultrasound oblique scan of the pancreatic gland with visualization of huge inhomogeneous fluid collection at the pancreatic body-tail.

Biliary stones represent the most frequent cause of acute pancreatitis, and they can be easily detected by US in the gall bladder and biliary tract with high diagnostic accuracy.

Normal US findings can be seen in patients with mild acute pancreatitis. Nevertheless, in most patients interstitial oedema can be observed, resulting in an enlargement of the gland with subsequent hypoechoic appearance, which can be focal or diffuse depending on the distribution (Figure 4). Focal pancreatitis generally occurs in the head of the pancreas, appearing as an hypoechoic mass, that is sometimes difficult to distinguish from a tumour.

Complications of acute pancreatitis include acute fluid collections that appear as hypo or anechoic areas, peripancreatic tissue necrosis or hemorrhage, parenchymal necrosis and vascular complications. These latter two are the most important complications of acute pancreatitis.

At contrast enhanced ultrasound (CEUS) the pancreatic segment involved by mild acute pancreatitis shows an increased contrast enhancement due to hyperemia. Severe acute

pancreatitis is characterized by the presence of large confluent necrotic areas and CEUS may improve the identification and delimitation of the these necrotic areas, which appear as avascular at dynamic imaging.

Chronic pancreatitis

Chronic pancreatitis is an inflammatory disease characterized by fibrosis, destruction and distortion of the pancreatic ducts with loss of parenchyma. It is clinically characterized by a progressive pancreatic functional loss. Although early morphologic changes of chronic pancreatitis are difficult to recognize at imaging, the findings of advanced disease are readily detected [Figure 6].

Figure 6 Chronic pancreatitis. Ultrasound oblique scan of the pancreatic gland shows main pancreatic duct dilation and calcifications.
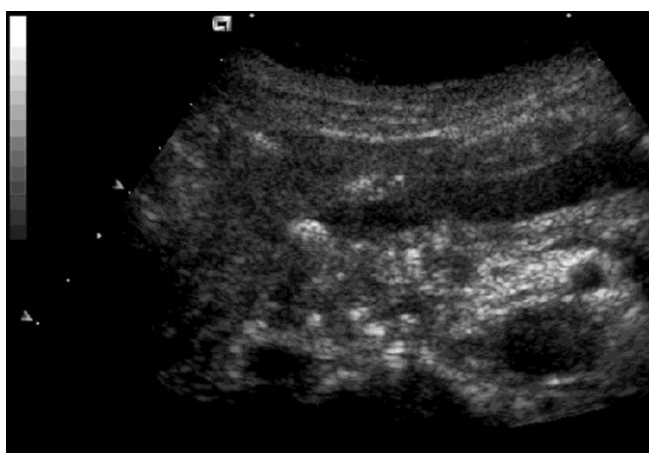
In the US study of chronic pancreatitis, alterations in size of the pancreas may be seen in about 50% of patients affected by chronic pancreatitis. Pancreatic atrophy and focal alterations in pancreatic size, expression of advanced stages, can be easily identified. The glandular contours appear irregular, sharp and sometimes lumpy.

The echogenicity of the pancreas may be increased in chronic pancreatitis due to fatty infiltration and fibrosis, although this is not an absolutely specific sign, since it can be also found in elderly and obese subjects. Parenchymal echostructure alterations, on the other hand, is a more specific sign, represented by inhomogeneous and coarse pancreatic echotexture due to the coexistence of hyperechoic and hypoechoic parts of fibrosis and inflammation respectively.

The most important diagnostic sign of chronic pancreatitis is the presence of calcifications that are calcium carbonate deposits, whose identification is pathognomonic. At US they appear as hyperechoic spots with posterior shading.

A further important sign of chronic pancreatitis is the dilatation of the main pancreatic duct (more than 3 mm), which even more often appears irregular in its course.

Nevertheless in the early phases of chronic pancreatitis the Wirsung duct may have a normal diameter. Moreover, compression of the main pancreatic duct may lead to secondary obstructive chronic pancreatitis upstream of the obstacle, with the same pathogenetic mechanism. Solid and cystic lesions may cause duct compression (benign) or infiltration (malignant) if contiguous to the main pancreatic duct, with progressive development of obstructive chronic pancreatitis upstream.

Autoimmune pancreatitis

Autoimmune pancreatitis is a rare cause of recurrent acute or chronic pancreatitis, with focal or diffuse affection of the gland. It is characterized by periductal inflammation, mainly sustained by lymphocytes and plasma cells infiltration, with evolution to fibrosis. In most cases, the echogenicity is reduced, the gland volume focally or diffusely (*sausage-like*) increased, and the pancreatic duct may be compressed by glandular parenchyma. US features include reduced echogenicity of the gland, diffuse or focal pancreatic enlargement, absence of any fluid collection or calcification. US findings are typical in the diffuse form when the entire gland is involved [Figure 7]. Focal autoimmune pancreatitis at the pancreatic head is often characterized by the dilatation of the common bile duct alone.

Figure 7 Autoimmune pancreatitis. Ultrasound oblique scan of the pancreatic gland shows diffuse enlargement of the gland with the typical ''sausage'' aspect in absence of any fluid collection or calcification.
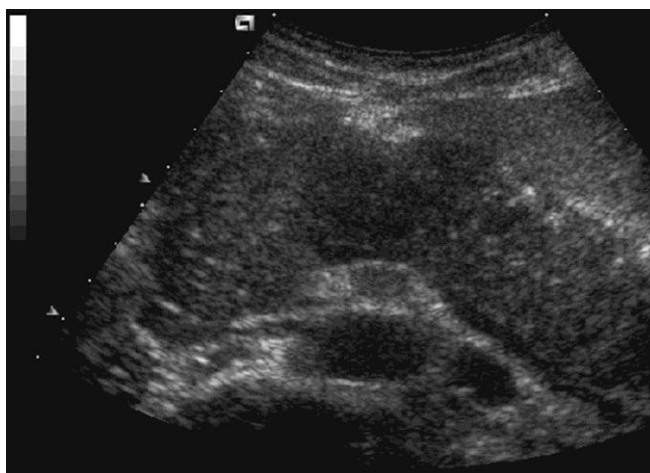
CEUS of autoimmune pancreatitis shows moderate diffuse enhancement in the early contrast enhanced phase, though inhomogeneous.

Contrast medium washout is usually slow but progressive. CEUS findings may be especially useful in the study of focal forms of autoimmune chronic pancreatitis, in which differential diagnosis with ductal adenocarcinoma is a priority. Typical appearance at CEUS is the isovascularization and so the isoechogenicity during the dynamic phases in respect to the adjacent parenchyma. Autoimmune chronic pancreatitis shows a remarkable response to steroid therapy because of its autoimmune pathogenesis.

Pancreatic focal inflammatory disease

Mass-forming pancreatitis

Mass-forming chronic pancreatitis usually occurs in patients with a history of chronic pancreatitis and must be differentiated from pancreatic ductal adenocarcinoma. At CEUS, a mass-forming chronic pancreatitis shows a "parenchymographic" enhancement,

characterized by an enhancement pattern always comparable to that of the surrounding pancreatic parenchyma. However, in long-standing chronic inflammatory processes, inhomogeneous hypovascularization of the lesion may be observed, probably owing to the presence of a large amount of fibrosis so the differential diagnosis becomes more difficult.

Pseudocyst

Pseudocyst of the pancreas is a fluid collection containing pancreatic enzymes, surrounded by a fibrotic wall with no epithelial lining. It can be a complication of severe acute pancreatitis [Figure 8] or occurs in chronic pancreatitis. Pseudocyst is caused by pancreatic ductal disruption following increased luminal pressure.

Figure 8 Pseudocyst. Ultrasound oblique scan of the pancreatic body shows huge rounded cystic lesion after severe acute pancreatitis.
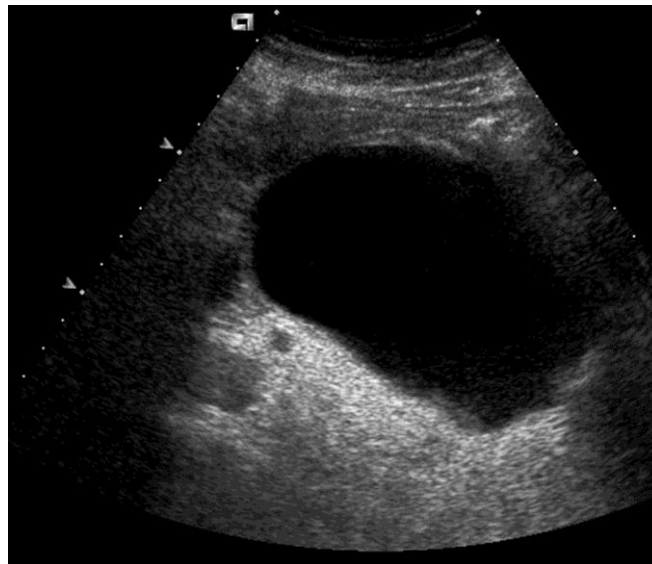
At US it appears as a sharply delineated and anechoic lesion, typically oval or round. Sometimes it may have inclusions (debris). The diagnosis of pseudocyst can be considered only if there is a history of acute or chronic pancreatitis. Pseudocysts must be differentiated from pancreatic cystic tumours (see below), as they require completely different therapeutic approaches. This is mainly possible thanks to the evaluation of the vascularity of intralesional inclusions, which are always completely avascular in pseudocysts, becoming homogeneously anechoic during CEUS examination. With this regard CEUS has a crucial role in differential diagnosis of pseudocysts and pancreatic cystic tumours, better evaluating the micro-vascularization of the intralesional inclusions.

Pancreatic solid neoplasms

Ductal adenocarcinoma

Ductal adenocarcinoma represents about 90% of pancreatic tumours. In almost two thirds of patients it is located in the head of the pancreas, while in the rest of them it involves the

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body and/or the tail, or it diffusely infiltrates the entire gland. Macroscopically, ductal adenocarcinoma appears as a scirrhous, homogeneous, infiltrating mass.

More frequently, at US, the adenocarcinoma appears as a solid hypoechoic lesion in respect to the adjacent pancreatic parenchyma, because of its marked desmoplasia, with infiltration and upstream dilation of the main pancreatic duct. When located in the head of the pancreas it causes a ductal obstruction with subsequent dilation of both the pancreatic duct and the common bile, resulting in the so-called "double-duct sign". A ductal adenocarcinoma is characterized by infiltrative margins with diffusion to the adjacent parenchyma and structures, resulting sometimes in difficultly to identify or delineate. In highly aggressive forms, necrosis and liquefaction are common, mainly centrally located.

Doppler study shows poor or no vascularity inside the lesion. The vascular invasion is defined by a focal absence of the echogenic interface of the vessel wall, or by a narrow lumen, with changes in blood flow velocity. The invasion of major peripancreatic vessels, together with the presence of liver or peritoneal metastases, represents the principal criteria of unresectable pancreatic cancer.

At CEUS, ductal adenocarcinoma shows a poor enhancement during all the dynamic study [Figure 9]. The margins and size of the lesion are more clearly visible. The depiction of tumoral margins at CEUS is more accurate with low enhancement of pancreatic adenocarcinoma, because in cases of well-differentiated lesions the mass tends to be isovascular compared to the remaining parenchyma and the margins of the tumour are no longer visualized. Relationship with peripancreatic arterial and venous vessels can also be evaluated for local staging.

Figure 9   Ductal adenocarcinoma. Contrast enhanced ultrasound transversal scan of the pancreatic head showing a markedly hypovascularized mass.
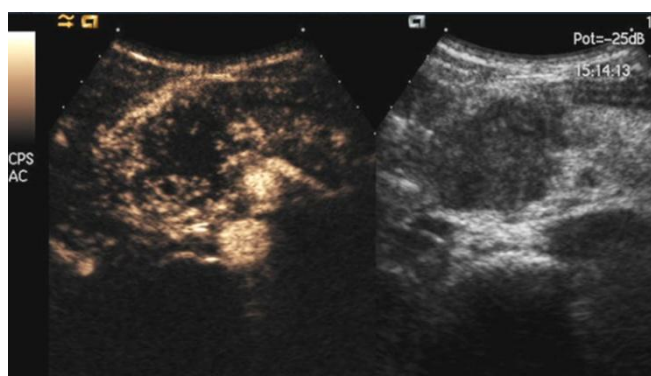
After studying a pancreatic lesion during the arterial, pancreatic and venous phases, the presence of liver metastases have to be excluded during the late phase.

Since US often represents the first technique performed, the use of CEUS will improve the diagnostic accuracy when a focal hypoechoic solid lesion has been detected.

Endocrine tumours

Pancreatic endocrine tumours or islet cell tumours arise from the neuroendocrine cells of the pancreas. These tumours are classified as functioning or nonfunctioning, based on the presence or not of clinical symptoms related to hormone production.

Insulinomas and gastrinomas are the most common functioning islet cell tumours and they are usually small at the time of diagnosis. The other functioning neuroendocrine tumours

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(vipoma, glucagonoma and somatostatinoma) are rare, account for about 20% of functioning neuroendocrine tumours of the pancreas. Nonfunctioning tumours are frequently large at diagnosis [Figure 10] and often malignant.

Insulinomas are usually benign and solitary pancreatic lesions, while gastrinomas tend to be malignant and multiple. Insulinomas represent the most frequently found functioning neuroendocrine tumour of the pancreas (about 60% of all neuroendocrine tumours), benign (85%–99%) and single (93%–98%) in the majority of cases. Insulinoma appears as a hypoechoic pancreatic nodule, usually capsulated.

Figure 10   Endocrine tumour (non-functioning). Ultrasound transversal scan of the pancreatic head shows large hypoechoic mass with well-defined margins and upstream main pancreatic duct dilation.
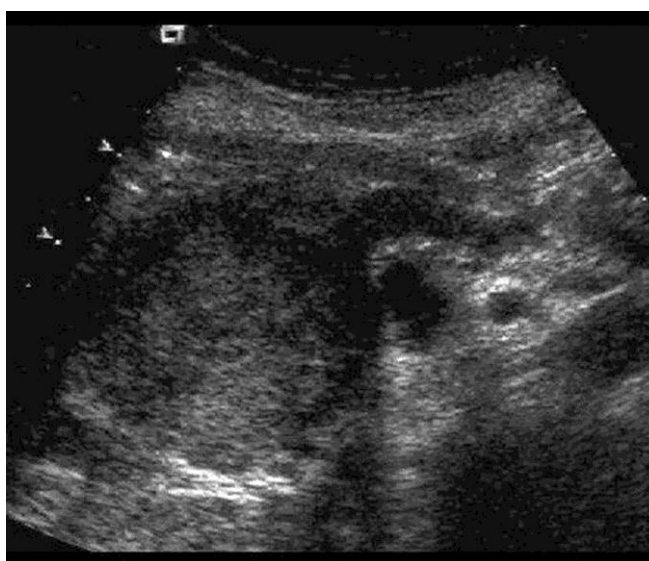
At the time of clinical presentation 50% of the tumours are smaller than 1.5 cm. When malignant their diameter is generally >3 cm and about a third of these have metastases at the time of diagnosis. The mean diameter of insulinomas is <15 mm, while gastrinomas are usually larger.

Gastrinomas are the second most frequently found functioning neuroendocrine tumours of the pancreas (about 20% of all neuroendocrine tumours). These tumours differ from insulinomas in localization and size. They occur within the gastrinoma triangle (junction of the cystic duct and common bile duct junction of the second and third parts of the duodenum junction of the head and neck of the pancreas), of which only the pancreatic side is correctly explorable by US. Identification of pancreatic gastrinomas can be easy considering their moderate size. Liver metastatic lesions are present in 60% of cases at the time of diagnosis.

Nonfunctioning islet cell tumors represent up to 33% of neuroendocrine tumours of the pancreas, ranging from 1 to 20 cm in diameter and showing a high malignancy rate, up to 90%. However they are less aggressive than adenocarcinomas. These tumours, characterized by predominantly expansive growth, are not clinically apparent until adjacent viscera and structures have become involved. At US they appear well marginated and usually easy to detect, thanks to their size. Due to their dimensions, necrosis and hemorrhage can be present, developing a typical inhomogeneous appearance, sometimes

accompanied by very small intralesional calcifications. Larger nonfunctioning islet cell tumours show cystic degeneration or cystic changes. The finding of numerous intratumoral vascular spots is typical of neuroendocrine pancreatic tumours at color-Doppler. In particular, a ''spot'' pattern can be demonstrated in both large and small endocrine tumours. However, while positive Doppler results predict hypervascularization of the lesion, a Doppler ''silence'' can also be present in hypervascular endocrine tumours because of the small size of the tumoral vascular network.

At CEUS, different enhancement patterns can be observed in relation to the size of tumours and tumoral vessels. Voluminous endocrine tumours show a rapid and intense enhancement in the early contrast enhanced phase, with the exception of necrotic intralesional areas. In moderate-sized neuroendocrine pancreatic tumours, a capillary blush enhancement can be present in the early contrast enhanced phase, then becoming hypoechoic in the late contrast enhanced phase.

Nonfunctioning neuroendocrine tumours can also be hypovascularized, depending on the amount of stroma inside the lesion which is dense and hyalinized.

Pancreatic cystic neoplasms

Serous cystadenoma

Serous cystadenoma (SCA) is a benign lesion, usually located in the head of the pancreas and generally characterized by tiny cysts of <20 mm. The content of the cysts is a glycogen rich serum, transonic at US. If extremely microcystic SCA can have a solid appearance at US and CT. In up to 15% of cases these tumours are characterized by a central scar, which may be calcified. US imaging can show the microcystic appearance of this lesion related to the sponge macroscopic aspect. The central scar, if present, is often visible as a central solid echogenic portion of the tumour, sometimes containing calcifications. The contours of the SCA are always quite sinuous and the wall is thin. The internal septa normally are well orientated and centrally directed, reaching the central scar with a definitive typical aspect of the skeleton of this cystic lesion. Numerous thin septa with a radial arrangement give to the lesion its typical microcystic aspect.

SCAs do not communicate with the main pancreatic duct. The demonstration of that is fundamental, especially when the lesion is large, because it might compress the main pancreatic duct, causing upstream dilation.

At CEUS, intralesional septa enhancement improves the identification of the microcystic features of the lesion. The less common oligocystic or macrocystic types of serous cystadenoma present features sometimes indistinguishable from those of the other macrocystic tumours of the pancreas.

Mucinous cystic neoplasms

Mucinous cystadenoma is a potentially malignant lesion. It is mostly located in the body or tail of the pancreas in middle-aged women. The content of the cyst is mucin. At US, it appears as round or ovoid, usually as an unilocular lesion with thick wall and septa and occasionally peripheral calcifications. The mucinous content is viscous and may generate fine echoes in the internal part of the lesion that covers the internal wall of the cystic tumour and may hide the inclusion such as internal septa, nodules and/or papillary projections. The number and the thickness of intralesional septa and nodules is not always

related to the grade of malignancy. Mucinous tumours may spread, involve lymph nodes and produce liver metastases.

CEUS may significantly improve the US detection of parietal nodules by demonstrating the vascularization of septa and nodules, standing out against the lesional background, anechoic during the dynamic imaging. Therefore CEUS examination improves ultrasonographic differential diagnosis between MCA and pseudocyst, thanks to the demonstration of the vascularization of vegetation in the cystic tumor.

Mucinous cystoadenocarcinoma represents the malignant neoplastic transformation of mucinous cystoadenoma. Compared to the latter it is characterized by thicker wall and septa, inhomogeneous content and a greater number of nodules (Figure 11), whose significant cell proliferation is responsible for wall and then peripheral structures invasion, leading to lymph nodes involvement and liver metastases development.

Figure 11 Mucinous cystadenocarcinoma. Ultrasound oblique scan of the pancreatic body shows huge rounded cystic mass with thick wall and several enhancing septa and nodules.
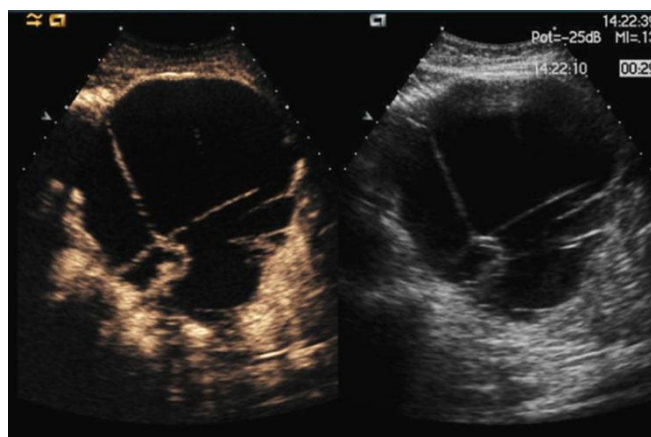
Intraductal papillary mucinous neoplasm

Intraductal papillary mucinous neoplasm (IPMN) is recognized as a dilation of the main pancreatic duct and/or its branches or cyst formation with proliferation of pancreatic ductal epithelium and excessive production of mucin. IPMNs are classified into the main duct type, branch duct type, or a combination of the two. IPMNs can be localized or diffuse. The localized main duct type of IPMN is characterized by highly inhomogeneous masses, related to neoplastic intraductal proliferation, with upstream dilation of the main pancreatic duct. The branch duct IPMN is characterized by cystic ectasia of one or more branches, forming masses.

At US, final diagnosis of IPMN by demonstrating the communication with the pancreatic duct is difficult. CEUS examination of the IPMNs may allow identification of intraductal papillary tumoral vegetations, especially in the papillary-villous variant, demonstrating its vascularization. CEUS can be a safe method to follow-up the borderline lesions evaluating changes in dimensions and vascularization of the inclusion. In this setting, CEUS has the great advantage of being a noninvasive and low cost technique.

Recommended reading

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