

Imaging the pancreas

The diagnosis of pancreatic disease can be challenging but has been improved in recent years with the introduction and advancement of various diagnostic tests. Tim Trevail BVetMed CertVDI DipECVDI MRCVS, European veterinary specialist in diagnostic imaging, discusses the various imaging modalities accessible to both general practice and at referral level for imaging the pancreas to complement the diagnostic tests that are now readily available

IMAGING OF THE NORMAL PANCREAS

The normal canine pancreas is not visible on survey radiographs due to its small size, relative similar opacity to the surrounding structures and location. For this reason, ultrasound has become the mainstay for imaging the pancreas in veterinary medicine due to its availability and relatively low cost compared with advanced imaging modalities.

ULTRASOUND

Ultrasound of the pancreas is challenging and its reliability is inherently dependent on machine quality and operator skill and experience. In addition, the patient's conformation and body condition are hugely influential on the image quality of the pancreas. For instance, the pancreas of a lean Shih-Tzu will be much easier to find and interpret than the pancreas of an obese Boxer.

Pancreatic parenchyma has similar echogenicity to the surrounding mesentery and therefore knowledge of several landmarks for identification of the body and left and right limbs of this organ is essential (Figure 1). The body of the pancreas can be found caudal to the body of the stomach in the angle between the pyloric antrum and the ascending duodenum. The main portal vein can also be used as a landmark for the body, as it lies in close proximity to the ventral wall of the body of the pancreas.

The right limb of the pancreas is ventral to the right kidney and medial to the descending duodenum (Figure 2). In barrel-chested dogs, the right limb can usually be traced from the body of the pancreas and with practice along the path of the descending duodenum from a ventrolateral approach. In deep-chested dogs, the right limb is easier to view from a lateral approach, again using the duodenum as a landmark. Viewing may require access via an intercostal

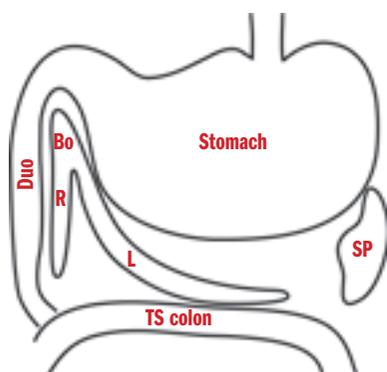


Figure 1: Schematic diagram of the feline pancreas from a ventral approach. The left limb (L) of the pancreas is more prominent in cats and can often be visualised from a window on the left flank through the spleen (SP), positioned caudal to the greater curvature of the stomach and cranial to the transverse colon (TS colon). The right limb (R) is squat in cats, but as in dogs roughly follows the path of the descending duodenum.

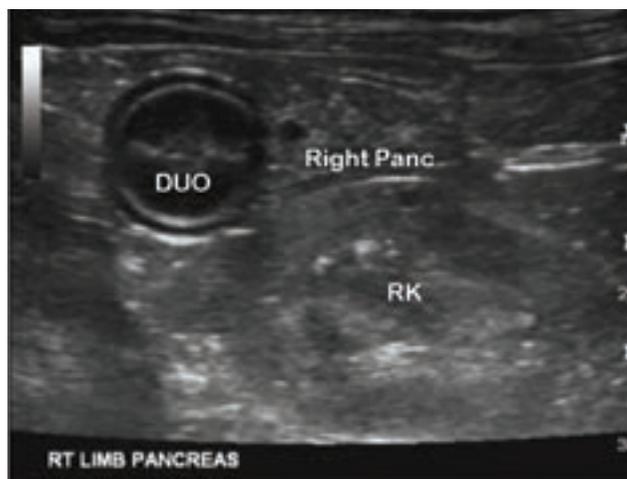


Figure 2: Transverse ultrasound image of the right limb of the pancreas in a dog. The duodenum (DUO) is shown in transverse adjacent to the triangular normal right limb of the pancreas (right panc). Note the similar echogenicity of the pancreatic parenchyma to surrounding mesentery. The right kidney (RK) is present in the far image.

approach. In cats, the right limb of the pancreas is smaller and, therefore, it can be slightly more difficult to identify. The left limb is more readily identifiable.

Landmarks for the left limb of the pancreas are the triad formed by the fundus of the stomach, transverse colon and spleen. More specifically, the left limb is closely associated with the splenic vein, which can be traced from the splenic hilus.

The normal pancreatic parenchyma has a similar echogenicity and echotexture to the surrounding mesentery, which is partly why it's such a tricky structure to identify. An anechoic tubular structure is often identified running through the parenchyma.

In dogs, this will usually represent the pancreatic vein (Saunders, 1991), while in cats this is usually the pancreatic duct which measures a mean of 1.3mm (range 0.5-2.5mm) in cats older than 10 years of age (Hecht, Penninck, Mahony et al, 2006; Figure 3).

COMPUTED TOMOGRAPHY

Computed tomography (CT) is widely used in human medicine for imaging the pancreas, particularly in the acute abdomen patient. Documentation of acute versus necrotising pancreatitis is important in people with regards to managing decision-making, with the latter considered to represent a surgical emergency. In veterinary patients, the problems posed by obesity remain a problem but to a lesser extent than in human medicine. For this reason,

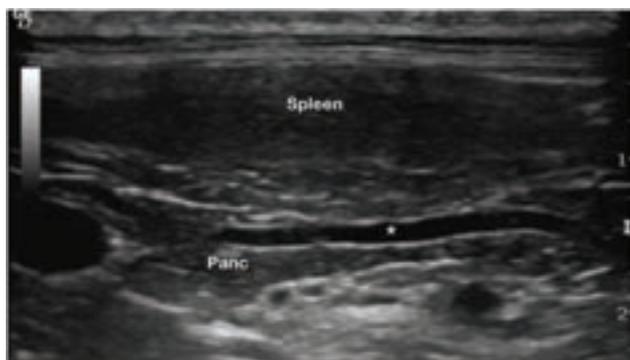


Figure 3: Ultrasound image of the left limb of the pancreas of a cat. Note the pancreatic duct running through the centre of the pancreas (*), a normal finding in cats.

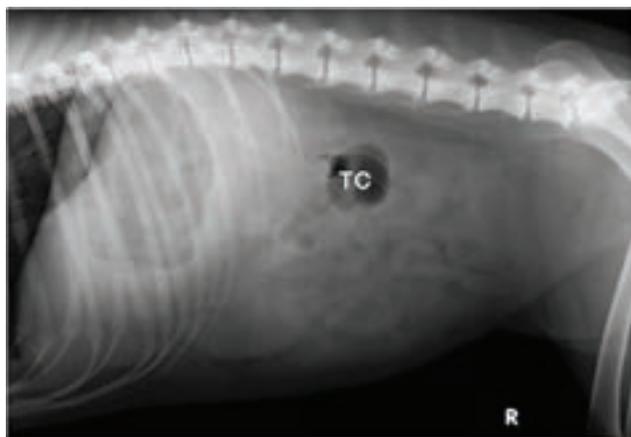


Figure 5: Lateral radiograph of a dog with confirmed pancreatitis. There is caudal displacement of the transverse colon (TC).

CT of the pancreas is mainly reserved for those cases where response to medical management has been poor and a complicating factor is suspected (such as abscess, pseudocyst, necrosis or primary pancreatic neoplasia) or for the identification, surgical planning and metastatic staging of insulinomas or suspected exocrine pancreatic neoplasia.

CT allows for excellent visualisation of the body, right and left limbs of the pancreas. With the use of intravenous iodinated contrast agents, CT allows for evaluation of the vascularisation of the pancreas and multi-slice CT allows differentiation of the vascular phases (arterial, portal-venous and late venous); (Caceres, Zwingenberger, Hardam et al, 2006).

MAGNETIC RESONANCE IMAGING

There is less documented use of magnetic resonance imaging (MRI) in veterinary medicine for pancreatic imaging. The normal appearance of the pancreas has been reported in cats (Newell, Graham Roberts et al, 2005; Marolf, Stewart, Dunphy et al 2011). The author has limited experience in the use of MRI of the pancreas and has personal preference for CT due to its reduced cost, speed of image acquisition and improved image quality over abdominal volumetric MRI sequences for multi-planar reconstruction.

PANCREATITIS

Pancreatitis is now a well recognised disease entity in both dogs and cats. The diagnosis of pancreatitis can be



Figure 4: Lateral radiograph of a dog with confirmed pancreatitis. There is reduced cranial abdominal serosal detail between the stomach and transverse colon, in the region of the pancreas.



Figure 6: Ultrasound image of pancreatitis in a dog. The enlarged hypoechoic pancreas is outlined by the asterisks. There is marked surrounding mesenteric reaction. The duodenum is seen in the near field.

suspected by a combination of clinical signs (vomiting, abdominal pain, diarrhoea, inappetence) and elevated amylase and lipase. A positive cPLI or fPLI is highly sensitive for the detection of pancreatic inflammation; however, the specificity of these tests is somewhat lower as, in addition to pancreatitis, pancreatic inflammation will also be seen in pancreatic adenocarcinomas, abscesses and secondary to inflammation of local organs, especially the stomach and duodenum (Watson, 2004).

RADIOGRAPHY

Radiography has a poor diagnostic accuracy in pancreatitis (Shanaman, Schwarz, Gal, 2013). The pancreas in healthy dogs is not visible on plain abdominal radiographs; the left limb occasionally is seen in healthy obese cats. Unless the pancreatic inflammation is moderate to severe, abdominal radiographs are often normal in appearance, therefore normal abdominal radiographs should not reduce the suspicion of pancreatitis.

Radiographic abnormalities of the pancreatitis include:

- Reduced serosal detail and increased opacity within the cranial abdomen along the caudal border of the stomach and descending duodenum. This is an area where there is often poor serosal detail in the normal patient, especially in a slightly underexposed radiograph, making interpretation of this area challenging (Figure 4);
- Caudal displacement of the transverse colon if the left limb or body of the pancreas is affected (Figure 5);

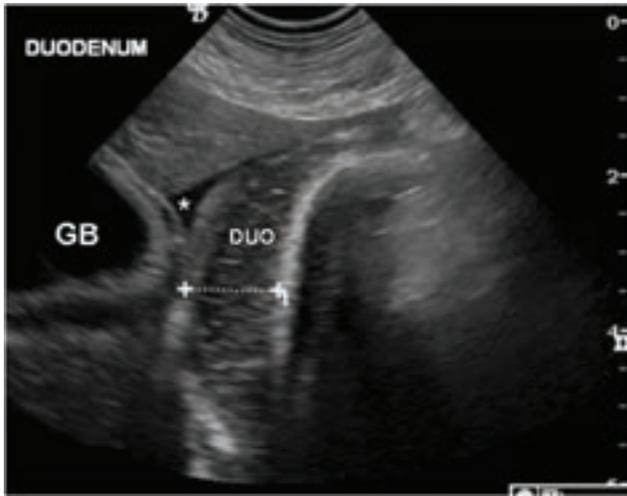


Figure 7: Ultrasound image of confirmed pancreatitis in a dog. The duodenum has a flaccid appearance consistent with ileus. In real time, fluid could be seen swashing back and forth with no propulsive peristaltic motions identified. There is also moderate thickening of the gall bladder wall (GB) and a small volume of free fluid (*).

- Lateroventral displacement of the duodenum if the right limb is affected;
- A dilated, spastic appearance of the duodenum due to ileus in cases of severe pancreatitis.

ULTRASOUND

Due to the poor sensitivity and specificity of radiography, ultrasound should be considered the imaging test of choice in cats and dogs with suspected pancreatic inflammation or in those with an elevated cPLI or fPLI. The role of ultrasound in these cases is to both identify pancreatic and peri-pancreatic inflammation whenever possible but also to try to discriminate pancreatitis from pancreatic masses such as possible neoplasms or complications of pancreatitis such as pseudocysts and abscesses which generally will require surgical or minimally invasive interventions. Careful evaluation of the gastrointestinal tract is essential as gastrointestinal pathology (especially duodenal foreign bodies or neoplasms) and inflammation can cause secondary pancreatic inflammation.

It should be noted that the diagnostic accuracy of ultrasound is less than perfect, especially in cats. The sensitivity of detecting pancreatitis in cats has been documented to be as low as 20-35% (Gerhardt, Steiner, Williams et al, 2001; Saunders, VanWinkle, Drobatz et al, 2002).

The classic appearance of acute pancreatitis on ultrasound is that of a hypoechoic mass-like structure with irregular margins (Figure 6). In addition there is marked contrast between the hypoechoic pancreatic parenchyma and the surrounding mesentery, which becomes very bright (hyperechoic) due to saponification. With marked mesenteric reaction, the fat becomes very attenuating to the ultrasound beam and this results in a hazy appearance surrounding the pancreas. Small amounts of free fluid adjacent to the pancreas may also be seen.

It is possible that specific areas of the pancreas such as just the right limb (more commonly in dogs) or just the left limb (more commonly in cats) are affected or that the whole of the pancreas is affected (Nyland, Mulvany, Strombeck, 1983). As already discussed above, ultrasound

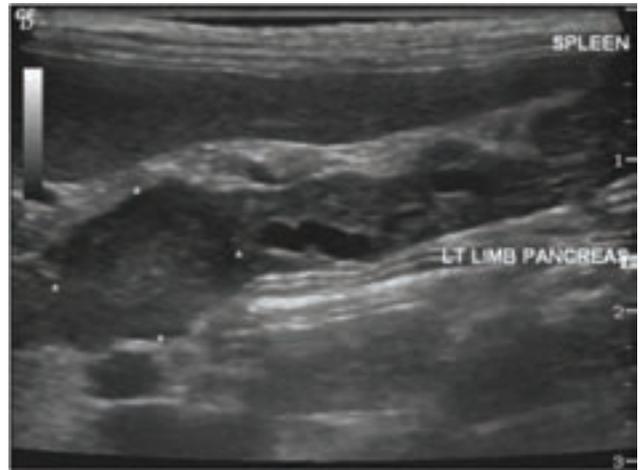


Figure 8: Ultrasound image of confirmed ductal adenocarcinoma in a cat. The image shows a large hypoechoic mass (outlined by asterisks) with surrounding reaction arising from the parenchyma at the junction of the body and left limb.

is by no means a one stop shop for the diagnosis of acute pancreatitis and in mild to moderate cases, the pancreas is likely to appear normal on ultrasound. The author has seen a few cases that have had a normal ultrasound on presentation and on re-scan 48 hours later have had a textbook appearance of pancreatitis. Therefore, repeat ultrasound is recommended for animals with suspected pancreatitis, which are non-responsive to medical management and a normal initial ultrasound.

With improved understanding of pancreatic pathology and marked improvement in ultrasound image quality in recent years, there is increasing recognition of changes within the pancreas on ultrasound consistent with chronic pancreatitis (Ferreri, Hardam, Kimmel et al, 2003). These changes are seen as hyperechoic irregular banding throughout the pancreas, which corresponds histologically with amyloidosis or fibrosis. Ultrasound provides valuable information in these cases as the presenting signs are often non-specific (inappetence, occasional vomiting, weight loss, etc) and the biochemical tests borderline due to the low-grade inflammation present.

With marked pancreatitis, it is not uncommon to observe ileus or intestinal reaction (usually seen as corrugation) affecting the adjacent intestinal loops, most commonly the duodenum (Figure 7). Mild thickening of the gastric or intestinal walls may also be noted, although wall layering is usually maintained (Saunders, VanWinkle, Drobatz et al, 2002).

Extrahepatic biliary obstruction (EHBO) may be observed where marked inflammation around the duodenal papilla is present. This occurs more commonly in cats due to the common entrance of the pancreatic duct and common bile duct at the major duodenal papilla. This is noted less commonly in dogs as the majority of the pancreatic juices drain into the minor duodenal papilla and therefore do not affect common bile duct drainage. The common bile duct should be examined in cases of pancreatic inflammation, with serial scanning recommended if the patient shows biochemical evidence of biliary obstruction. A dilation of the common bile duct greater than 4mm in cats (Leveille, Biller, Shiroma, 1996) and 3.6mm distally and 4mm proximally in dogs (Miller, Brinkman-Ferguson, Mackin et al, 2013) is considered pathological.

Pancreatic pseudocysts or abscesses are an uncommon



Figure 9: CT image post-contrast at the level of the pancreatic body during the portal phase showing a heterogeneously enhancing mass within the body of the pancreas (between asterisks), just to the right of the portal vein (PV).

sequelae or contributing factor to pancreatitis and will be discussed later.

PANCREATIC NEOPLASIA

Exocrine pancreatic neoplasia

The most common malignant pancreatic neoplasms in both dogs and cats are adenocarcinomas arising from the exocrine acinar or ductal epithelial cells, although these are uncommonly encountered.

As with pancreatitis, radiography provides limited diagnostic information with regards to pancreatic neoplasms. On ultrasound, exocrine pancreatic neoplasia appears as a hypoechoic mass with surrounding mesenteric reaction (Hecht, Penninck, Keating, 2007; Figure 8), hence there is an overlap in the ultrasonographic appearance between exocrine pancreatic neoplasms and pancreatitis. These neoplasms generally arise from the body of the pancreas and because of their close proximity to the pyloric antrum and duodenum, may invade these structures, and therefore are usually challenging or impossible to surgically resect.

The role of ultrasound in these cases is to confirm the origin of the mass as arising from the pancreas whenever possible to aid in surgical decision-making and to obtain guided biopsies, either via fine needle aspirates or trucut biopsy. These cases often have free fluid either locally surrounding the pancreas or throughout the peritoneal cavity. Obtaining a sample of this fluid is recommended as the tumours exfoliate into the fluid and can often provide a diagnosis from the fluid alone.

Endocrine pancreatic neoplasia

Insulinomas are the most commonly encountered endocrine pancreatic neoplasms, although these are considered rare (Robben, Pollak, Kirpensteijn et al, 2005). Glucagonomas, gastrinomas and somatostatinomas are rarer and poorly documented in the veterinary literature. All these neoplasms are usually malignant and have a high metastatic rate, most commonly to the draining lymph nodes (pancreatoduodenal and/or hepatic lymph nodes) and liver. Approximately 40-50% of insulinomas are reported to have gross metastatic disease at surgery. The aim of imaging insulinomas is whenever possible



Figure 10: CT image post-contrast of a dog with an insulinoma at the level of the hepatic LNs during the portal phase. The hepatic lymph node (<) is enlarged and shows moderate enhancement relative to the surrounding nodal tissue during the portal phase suggestive of metastatic disease, which was confirmed at surgery. The aorta (Ao), caudal vena cava (CVC) and portal vein (PV) are all enhanced with contrast.

to confirm the presence of a nodule/mass within the pancreas, assess for the presence of metastatic disease and to evaluate the location of the mass with respect to surgical resectability. Ultrasound is reportedly poorly sensitive in the detection of insulinomas with sensitivity of just 33% (Robben, Pollak, Kirpensteijn, et al, 2005).

DUAL-PHASE CT ANGIOGRAPHY

Dual-phase CT angiography markedly improves the assessment of the pancreas for insulinomas and for metastatic disease (Robben, Pollak, Kirpensteijn, et al, 2005). The term dual-phase refers to the acquisition of scans during both the arterial and portal-venous phases following intravenous contrast medium administration in addition to non-contrast enhanced scans. Timing of the scan, to obtain a true arterial phase in particular, is essential and generally requires a contrast injector pump and bolus-tracking software in addition to a multi-slice CT scanner (≥ 4 slices).

The pancreas has rapid contrast enhancement during the arterial phase and a prolonged portal-venous phase. Insulinomas and their metastases have even more marked arterial enhancement, highlighting them from surrounding normal parenchyma, whether within the pancreas, liver or lymph node (Figures 9 and 10).

MRI FINDINGS

MRI findings of insulinomas are not reported in the veterinary literature. The author has limited experience in the MRI of such tumours, preferring CT. Acquisition times must be kept to a minimum to limit breathing artefacts. On T2-weighted images, pancreatic neoplasms are hyperintense to surrounding pancreatic parenchyma and show marked contrast enhancement on T1-weighted images post-intravenous gadolinium administration.

NODULAR HYPERPLASIA

Nodular hyperplasia or adenomas are uncommonly encountered in the pancreas of dogs and cats but are an important differential diagnosis for malignant neoplasms,

especially of endocrine tumours due to their nodular appearance (Hecht, Penninck, Keating, 2007).

PANCREATIC MISCELLANY

Pancreatic pseudocysts are uncommon in veterinary practice. They are usually associated with pancreatitis and are most often identified within the left limb of the pancreas (VanEnkevort, O'Brien, Young, 1999). Ultrasound appearance is of a hypoechoic-anechoic cavitated region within or adjacent to an enlarged (hypoechoic) pancreas with surrounding mesenteric reaction. Drainage of these structures can be performed under ultrasound guidance for both a diagnostic sample and for therapeutic relief. Drainage has not been associated with morbidity in both the literature and the author's experience. Pancreatic abscesses are a differential for pseudocysts and are considered rarer. The sonographic appearance is similar although may be associated with a more marked mesenteric reaction. The content is typically sterile. Surgical management is associated with a poor prognosis according to the literature (Salisbury, Lantz, Nelson, 1988; Anderson, Cornell, Parnell et al, 2008). In the author's limited experience with such pathology, the outcome is favourable with percutaneous drainage and medical management of sterile abscesses.

INTERVENTIONS

Routine aspiration of the pancreas is not performed due to the potential of inducing pancreatic inflammation and the relatively poor diagnostic yield. Fine needle aspiration is reserved for those cases where a pancreatic neoplasm is suspected, with the exception of insulinomas where the

diagnosis has usually been attained prior to the ultrasound examination. There is a risk of tumour seeding along the needle path, therefore the benefits of sampling should be considered prior to intervention (Vignoli, Rossi, Chierici et al, 2007; Pasieka, Thompson, 1992).

Drainage of pancreatic pseudocysts or abscesses percutaneously with ultrasound guidance should be considered if present. The risk of leakage into the peritoneal cavity should be evaluated and a decision based on the risk:benefit assessment should be taken in light of the clinical status of the patient. Serial scanning of these cases should be performed whether drainage is performed or not, to assess for leakage, recurrence or resolution.

CONCLUSIONS

Ultrasound is a useful adjunct to blood tests in the diagnosis of pancreatic disease but is operator and machine dependent. It should be borne in mind that a normal ultrasound does not rule out pancreatic disease. Radiography provides limited information with regards to the pancreas, but is useful to evaluate for gastrointestinal pathology (especially foreign bodies) in the vomiting dog. CT and MRI are currently used sparingly in the diagnosis of pancreatic disease; however CT should be considered the imaging gold standard for evaluation of pancreatic neoplasms (especially insulinomas) with respect to evaluation for surgical resection and metastatic disease.

REFERENCES AVAILABLE ON REQUEST

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Reader Questions and Answers

1: REGARDING THE ANATOMY OF THE CANINE PANCREAS, WHICH OF THE FOLLOWING STATEMENTS IS CORRECT?

- A: The left limb of the pancreas is easier to find on ultrasound examination.
- B: The right limb of the pancreas is closely associated with the descending duodenum.
- C: The body of the pancreas lies in close association with the ventral aspect of the caudal vena cava.
- D: The caudal tip of the left limb of the pancreas is closely associated with the cranial aspect of the left kidney.
- E: Landmarks for the left limb of the pancreas are the main portal vein, descending colon and spleen.

2: REGARDING THE NORMAL SONOGRAPHIC APPEARANCE OF THE PANCREAS, WHICH OF THE FOLLOWING STATEMENTS IS TRUE?

- A: Normal pancreatic parenchyma is markedly hypoechoic to adjacent mesentery.
- B: An anechoic tubular structure running through the centre of the right or left limb of the canine pancreas usually represents the pancreatic duct.
- C: An anechoic tubular structure running through the centre of the right or left limb of the feline pancreas usually represents the pancreatic duct.
- D: The left limb of the feline pancreas is more difficult to find due to its smaller size.
- E: The body of the pancreas in canines usually measures up to 5cm in thickness.

3: RADIOGRAPHIC FEATURES OF PANCREATITIS IN DOGS INCLUDE (CHOOSE THE CORRECT ANSWER):

- A: Cranial displacement of the transverse colon and focal loss of serosal detail.
- B: A gas/fluid dilated dorsomedially displaced descending duodenum.
- C: A gas/fluid dilated dorsally displaced descending colon.
- D: A focal loss of serosal detail in the cranial abdomen along the caudal border of the stomach and descending duodenum.
- E: Hepatomegaly and caudal displacement of the gastric axis.

4: THE CLASSIC APPEARANCE OF SEVERE ACUTE PANCREATITIS ON ULTRASOUND IS:

- A: A hypoechoic mass-like lesion with increased echogenicity of the adjacent mesenteric fat resulting in increased contrast.
- B: Corrugation of the small intestines.
- C: Hyperechoic irregular banding of the pancreatic parenchyma consistent with amyloidosis/fibrosis.
- D: Duodenal ileus.
- E: Dilation of the common bile duct.

ANSWERS: 1: B, 2: C, 3: D, 4: A