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Feline Ultrasound Mini Series

Session Two: Abdominal Ultrasound 2

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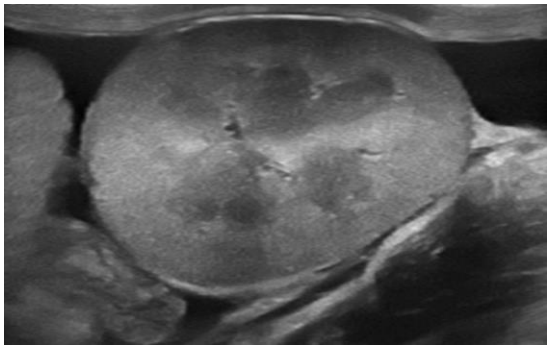


The Feline Gastrointestinal Tract

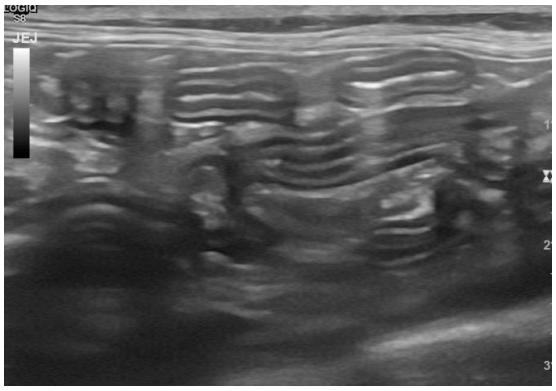
Normal appearance and location

The stomach is located immediately caudal to the liver. Ultrasonographically the normal empty stomach has what is sometimes referred to as a 'wagon wheel' appearance due to the prominent rugal folds of the gastric fundus. In some cats, the gastric submucosa contains a layer of hyperechoic fat creating a stripy appearance. It may be possible to see this on radiographs as an intramural radiolucent band within the gastric wall which should not be mistaken for gas. It is important that the stomach is examined methodically and it should be possible to examine the entire stomach starting with the fundus on the left, followed by the body and finally the pylorus. Compared with dogs in which the pyloroduodenal angle is located on the far right side of the abdomen, in cats it tends to be located more towards the midline. Since the pylorus is more midline in cats, it is often possible to examine it ultrasonographically from a ventral midline approach with the cat in right lateral recumbency. Alternatively, the pylorus may also be found by scanning the right cranial quadrant of the abdomen with the cat in left lateral recumbency and following the descending duodenum proximally (cranially) until the pyloroduodenal junction is reached. Typical inter-rugal gastric wall thickness in cats is around 2.2mm. Great care should be taken to ensure callipers are placed across the gastric wall between the rugal folds so as to avoid measuring rugal fold thickness which will always lead to false diagnosis of wall thickening.

The pylorus may be recognised just to the right of midline as the stomach narrows or assumes a 'pinched' appearance. From here, the pylorus can be traced to the descending duodenum. With practice, the duodenal papilla is easily located within the proximal descending duodenum as a focal soft tissue bulge in the wall. In dogs the common bile duct and pancreatic duct enter the duodenum separately whereas in cats, the two ducts enter the duodenum jointly at the same papilla. This difference in morphology accounts for why we see triaditis more commonly in cats as bacteria from the gastrointestinal tract can simultaneously gain access to the biliary and pancreatic systems.

In cats, the duodenum is the same thickness as the jejunum 2-2.5mm (in dogs the duodenal wall is thicker than the jejunum). The descending duodenum follows a fairly straight path caudally along the right lateral body wall. It then turns cranially at the caudal duodenal flexure and travels for a short distance before becoming the jejunum. There are no specific landmarks to mark this junction. In empty intestinal loops in transverse section, the echogenic lumen appears to extend into the mucosal layer of the wall on either side. This is a normal appearance and is thought to be due to altered positioning of intestinal villi in collapsed bowel segments. The ileum in cats is a short length of bowel just proximal to the ileocolic junction and is easily recognised by a prominent hyperechoic submucosal layer and a prominent muscularis layer. Normal ileum wall can measure up to 3.5mm. The ileum can be traced to the ileocaecocolic junction which is much easier to see ultrasonographically in cats than in dogs as the caecum tends to be fluid-filled rather than gas-filled as in the dog. The caecum can be identified as a conically-shaped blind-ending pouch at the level of the ICCJ. The ascending colon can be located by sliding the probe just cranial to the ICCJ. The colon is made up of three parts. In order, these are the ascending colon, followed by the transverse colon and final the descending colon. Colon is readily differentiated from small intestine by its much thinner wall which typically measures only 1-2mm thick. The colon often contains gas and faeces and it is common for the resultant distal acoustic shadowing to limit visibility of the distal colonic wall.

Five layers can routinely be identified in the wall of the gastrointestinal tract on ultrasound. The inner most 'layer' is not really a layer per se but is the luminal-mucosal interface which is typically represented by a thin echogenic line when the intestine is empty. The next layer – the mucosa - is a hypoechoic and relatively thick layer in the small intestine and contributes significantly to overall wall thickness. The submucosa lies deep to the mucosa and is represented by a hyperechoic stripe. Deep to this is the muscularis layer which is hypoechoic and should be thinner than the mucosal layer in the small intestine except during peristalsis when the mucosa and muscularis layers may assume the same thickness. The final and outermost layer is the serosa and is represented by a fine hyperechoic line.



Normal jejunal loops

Pathology of the gastrointestinal tract

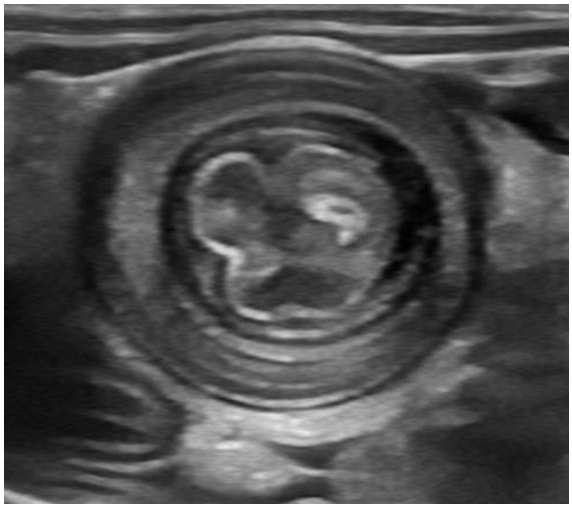
Linear Foreign bodies

Linear foreign bodies such as string are particularly common in cats. Part of the foreign material becomes anchored around the base of the tongue (more common in cats) or in the pyloric antrum (more common in dogs) whilst the remainder travels distally into the small intestines. Peristalsis causes the intestines to 'climb up' the foreign material leading to intestinal plication. If left undetected the foreign material can cheese-wire through the intestinal wall leading to perforation and septic peritonitis. Radiographs can be helpful in the diagnosis and may reveal bunching of small intestine and abnormal round or 'tear-drop' shaped intestinal gas. Ultrasound is usually performed to confirm a suspicion of linear foreign body. As for non-linear foreign bodies the ultrasonographic appearance will depend on the exact nature of the foreign material however typically, the linear foreign body will appear as an echogenic (bright) line running through the middle of plicated intestine and is commonly associated with shadowing. Since linear foreign bodies usually only cause a partial obstruction, it is quite common for there to be little to no intestinal dilation. Round worms in the intestinal lumen can mimic a linear foreign body however there is no associated plication of the intestine and movement of live worms can usually be observed.

Intussusception

Intussusception occurs when one part of the intestine (the intussusceptum) telescopes into the lumen of adjacent segment of intestine (the intussuscipiens). This can occur anywhere including at the pyloroduodenal junction (gastroduodenal intussusception) although this is rare and the condition more commonly occurs at the ileocolic junction. Intussusception can be seen in puppies and kittens with diarrhoea +/- intestinal parasites due to intestinal hypermotility. In older animals however, intussusception is less common and may be secondary to another condition such as intestinal neoplasia or less commonly, foreign body obstruction.

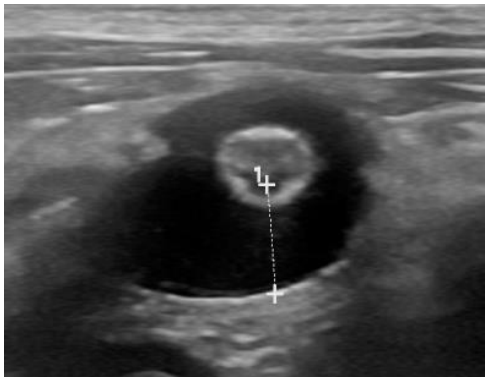
On ultrasound, the affected segment of gut has a concentric ring appearance also known as a ‘ring sign’ due to the walls of the intussusceptum and intussuscipiens being superimposed onto one another. Hyperechoic material may be present within the lumen of the intussuscipiens and adjacent to the intussusceptum due to mesenteric fat being drawn in with the latter. Over time, the wall of the intussuscipiens segment becomes thickened and hypoechoic and wall layering may become less discernable due to a combination of oedema and compromise to blood flow. Often the intussusceptum retains a normal appearance. Colour Doppler ultrasonography can be used to assess blood flow within the mesentry of the intussuscepted bowel. The presence of blood flow is suggestive of a reducible intussusception. The opposite is also true whereby lack of blood supply indicates the intussusception is more likely to be non-reducible.



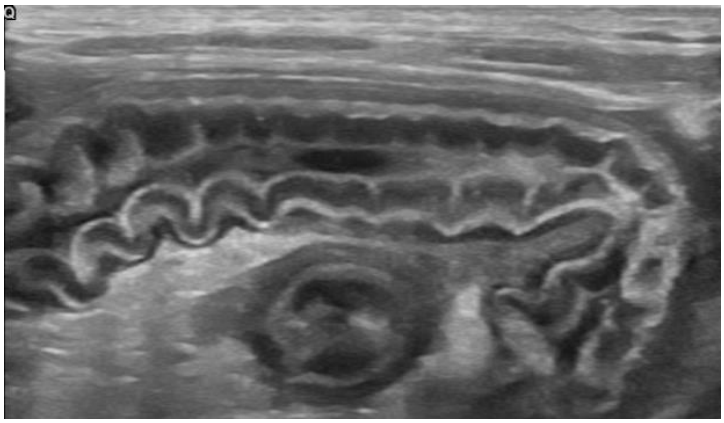
Intussusception

Inflammatory Disease

Inflammatory intestinal disease is a relatively common indication for ultrasound of the gastrointestinal tract. Often there are no ultrasonographic changes discernable. When ultrasonographic changes secondary to inflammatory disease IBD are present, they tend to be diffuse. One of the most common changes is mild to moderate symmetrical thickening of the intestinal wall although this is not considered a specific finding. In cats, the muscularis layer of the small intestine can become thickened in chronic inflammatory disease and can even exceed the width of the submucosal layer. Thickening of the muscularis layer is not pathognomic for inflammatory disease however and can be seen in cats with lymphoma and secondary to chronic mechanical obstruction. Wall layering is typically retained in inflammatory disease and loss of visible wall layering is uncommon unless inflammation is severe and wall oedema or haemorrhage are present. Other wall changes that may be observed in inflammatory disease include altered echogenicity (particularly increased echogenicity of the mucosal layer) and mild corrugation (small intestine only). Corrugation is diagnosed when the intestinal wall has an undulating or wavy appearance and should not be confused with plication which occurs when the intestines become bunched up due to a linear foreign body. Corrugation is also a non-specific finding and can be seen in cases of bowel infarction, peritonitis, pancreatitis (duodenum specifically affected) and intestinal neoplasia. In some cats it may be possible to identify a thin hyperechoic band within the mucosal layer of the small intestine that parallels the submucosa. This band is thought to represent a zone of mucosal fibrosis however it has been identified in both cats with and without clinical signs of gastrointestinal disease and hence its clinical significance is not fully understood at present.



Marked thickening of the muscularis layer of the ileum.



Intestinal Corrugation

Neoplasia

Lymphoma is the most common gastrointestinal tumour in the cat. Typically, lymphoma of the stomach or intestine is associated with loss of wall layering, focal transmural thickening, hypoechogenicity of the wall, reduced motility and local lymphadenopathy. Lymphoma can present as multiple intestinal masses and as previously mentioned, can also present as diffuse thickening of the muscularis layer with otherwise normal wall layering. The relevant gastric or jejunal lymph nodes should be assessed as these are often involved

Intestinal lymph nodes

The jejunal lymph nodes are located at the root of the mesentry in the mid-abdomen adjacent to the cranial mesenteric artery. They are visible in the vast majority of cats and may be located by scanning the mid-abdomen and are usually found just caudal to the spleen. They are the largest lymph nodes (on average 4-5mm diameter) in the abdomen and usually have an elongated, slender appearance, thin echogenic wall and are mildly hypoechoic to isoechoic relative to the surrounding tissue. The ileocecal lymph nodes can be identified either side of the caecum and measure on average 3-4mm diameter. When abnormal, due to reactive or neoplastic disease, these lymph nodes may become enlarged, hypoechoic and rounded.

Fine needle aspiration of the Intestinal wall

The main concern with regards to sampling the intestinal wall is accidental penetration of the intestinal lumen by the needle and tracking of bacteria to the peritoneum resulting in peritonitis.

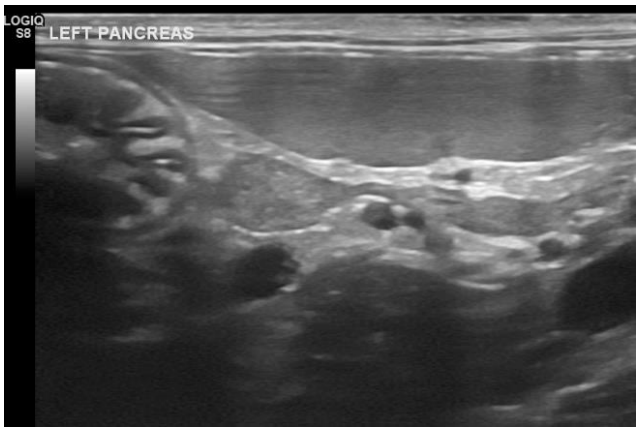
To reduce the risk of this happening, the section of intestine with the greatest degree of wall thickening should be chosen for sampling and the needle should be directed into the wall at a relatively shallow angle. It is important to be able to see the tip of the needle at all times. This is helped by the fact that the needle is easier to see when introduced at a shallow angle compared with a steep angle since more echoes return from the needle to the transducer.

Pancreas

The left limb of the pancreas is located between the greater curvature of the stomach cranially and the transverse colon caudally. The tip often extends medial to the head and body of the spleen. The right limb of the pancreas lies dorsomedial to the descending duodenum. The two limbs are joined by the body of the pancreas which can be found just caudal to the pyloroduodenal angle.

The average thickness of the feline pancreas is around 5mm however much variation is possible. The left lobe and body, being larger, are usually easier to locate than the smaller right lobe in cats. This is in contrast to dogs where the right lobe of the pancreas is usually the easiest portion to identify.

Identification of adjacent structures is often key to the identification of the pancreas. The left lobe of the pancreas is identified most easily from a left flank approach with the animal in right lateral recumbency. The left limb of the pancreas may be identified in the centre of a triangle created by the stomach cranially, the transverse colon caudally and the spleen laterally. The portal vein is consistently seen dorsal to the pancreas at the level where the left limb meets the body and can be followed to the hepatic hilus. The pancreas is isoechoic to slightly hypoechoic relative to surrounding fat. Relative to other organs, the pancreas is usually hypoechoic relative to the spleen and hyperechoic relative to the liver. Identification of the pancreatic duct is often key to identifying the normal pancreas which is often otherwise difficult to see. The pancreatic duct is a tubular anechoic structure, with thin hyperechoic walls, that runs within the left limb of the pancreas, parallel to its longitudinal axis. If in doubt, colour Doppler may be used to demonstrate an absence of flow within the duct which normally measures around 1mm in thickness. The right limb of the pancreas lies dorsomedial to the descending duodenum. To locate the right limb, the duodenum should first be identified in longitudinal. The probe is then rotate 90 degrees and the pancreas is seen in transverse cranial to the duodenum.



Normal Left pancreatic Limb

One of the most common abnormalities of the pancreas, is pancreatitis. Typical findings in acute pancreatitis include an enlarged, hypoechoic pancreas, hyperechoic peri-pancreatic fat +/- a small volume of peritoneal fluid usually in the region of the pancreas.

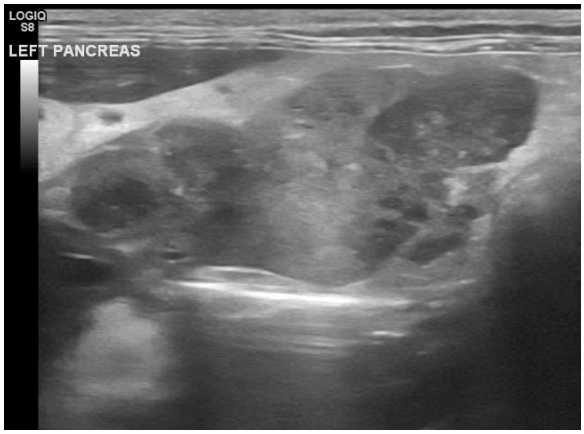
The descending duodenum may appear corrugated and mildly fluid-dilated due to localised secondary duodenitis and in some cats this may be the only sign of pancreatitis. Pancreatitis may be mild, moderate or severe and affect the pancreas focally, or as diffuse or multifocal disease. In cats the body and left limb are more commonly involved (compared with dogs where the right limb is more commonly inflamed). It is not uncommon, for only one or two of these findings to be present however this is usually sufficient for a presumptive diagnosis of pancreatitis to be made. Obstruction of common bile duct may be present as a complication of pancreatic inflammation. The distal aspect of the duct is compressed and bile is unable to flow into the duodenum causing the common bile duct to dilate proximally.

Unfortunately, the sensitivity of ultrasound in the detection of feline pancreatitis is limited and the pancreas in affected cats often appears normal. Therefore, the presence of an ultrasonographically normal pancreas cannot be used to rule out the possibility of pancreatitis.

Pancreatic cysts can be divided up into three types: congenital cysts, pseudocysts and retention cysts. Congenital cysts are true cysts present at birth and are usually incidental. Pseudocysts form following pancreatitis and rupture of a duct within the pancreas. They have a fibrous capsule and are filled by pancreatic secretions and necrotic debris. They are called pseudocysts because of a lack of a true epithelial lining. Retention cysts form due to blockage of a duct and accumulation of glandular secretions. Cats with polycystic kidney disease may also develop cysts within the liver and pancreas. Differentiation between different types of cysts is not possible based on ultrasound appearance and is largely academic..

Pancreatic abscess formation is uncommon particularly in cats but may develop secondary to pancreatitis. Abscesses can be highly variable in appearance but the typical presentation is a thick-walled cavitated lesion with hyperechoic or flocculent contents. Occasionally gas may also be present.

Pancreatic neoplasia is rare in cats and associated with a poor prognosis. Adenocarcinoma is the most common neoplasm of the exocrine pancreas. Free abdominal fluid and lymphadenopathy are frequent concurrent findings. Lymphoma may also affect the pancreas and can present as generalised enlargement of the pancreas or focal nodules or masses. Solitary masses exceeding >2cm diameter in at least one dimension, are reported to be more likely to be neoplastic. Tissue sampling is vital however, since nodular hyperplasia, which typically presents as multiple nodules <1cm diameter within the pancreas, can mimic pancreatic neoplasia and is a common incidental finding in older cats.



Lymphoma of the Pancreas

The Urinary Tract

The feline kidneys are typically oval in shape and are usually relatively easy to find as they tend to be more caudally located in the abdomen compared with dogs and hence it is not normally necessary to use an intercostal approach. Their superficial location in the abdomen lends itself to the use of a high-frequency transducer ($\geq$ 7.5MHz).

Top Tip: The kidneys are located quite dorsally in the abdomen therefore if you find yourself struggling to find one or both kidneys, consider extending the clip area further dorsally as you may be scanning too ventrally.

Since the feline abdomen is relatively narrow, it is possible to scan both kidneys from the same side. Therefore, the left kidney could inadvertently be mistaken for the right kidney and vice versa. Since feline kidneys are quite mobile, they can move around slightly when pressure is applied with the transducer. Therefore it is not necessarily accurate to assume that the more caudal kidney is the left kidney particularly and vice versa. Determining whether a kidney is the left or right kidney is important when a unilateral lesion is identified and even more so if nephrectomy is being considered. The safest way to identify which kidney is being imaged is to compare it with the major abdominal vessels – the caudal vena cava and aorta. With an animal in right lateral recumbency and the probe on the left flank, the left kidney will be superficial to the caudal vena cava and aorta whereas the right kidney will be deep to these vessels. The opposite is true with the animal in left lateral recumbency using a right flank approach. If there is still doubt, place the cat into dorsal recumbency and allow each kidney to fall to its respective side and re-image.

Renal length in normal cats varies from around 3cm to 4.5cm. A study in 2013 reported average renal size in the cat breeds: Sphynx cats (4.09 ± 0.33 cm), British Shorthair (3.77 ± 0.43 cm) and Ragdoll cats (3.87 ± 0.41 cm). In some large breeds such as the Maine Coon, kidney size may naturally be slightly larger and fall outside the normal range (i.e. >4.5cm). Intact cats also tend to have slightly larger kidneys (although most cats we scan nowadays are neutered) and older cats may have slightly smaller kidneys (2.8cm -3 cm).

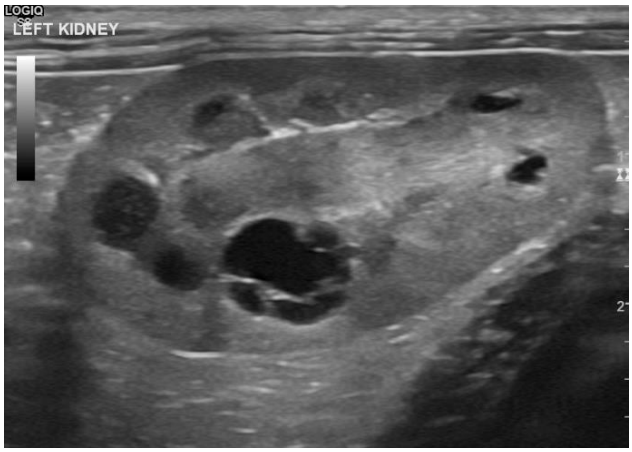
The normal kidney consists of a capsule, an outer cortex, an inner medulla and a collecting system. The thin echogenic capsule that surrounds the kidney is usually only partly visible where the capsule is perpendicular to the beam. At non-perpendicular angles, echoes from the capsule are deflected away from and hence do not return to the transducer. It is common for the renal cortices of older cats to appear hyperechoic. This is most often due to fat deposition within the renal tubules of the cortex leading to increased corticomedullary definition. The renal pelvis may be very mildly dilated and up to around 3mm in diameter in normal cats or in cats on intravenous fluids or diuretics. The peri-pelvic sinus often appears hyperechoic due to the presence of fat and as such may exhibit distal acoustic shadowing making differentiation from nephrolithiasis sometimes challenging.

Corticomedullary definition is a term used frequently in the ultrasonographic evaluation of the kidneys and is a subjective assessment of the difference in echogenicity between the cortex and the medulla. A normal kidney has good corticomedullary definition. An abnormal kidney in which the medulla is increased in echogenicity such that it is difficult to determine where the cortex ends and the medulla begins, is said to have poor corticomedullary definition. It should be borne in mind that this is a non-specific finding however and may be seen with a wide range of conditions.

In some cats a medullary rim sign may be visible. This is a hyperechoic band within the medulla that parallels the corticomedullary junction. It may be identified in association with a number of conditions including ethylene glycol toxicity (causes acute tubular necrosis), hypercalcaemic nephropathy and feline infectious peritonitis. It is also commonly identified in cats without any clinical evidence of renal disease, particularly older cats due to mineral deposits within the lumina of renal tubules. Therefore, a medullary rim sign is a common finding in cats of questionable significance that should be interpreted with caution as in many instances it is considered to be an incidental finding

The most common neoplasm to affect the feline kidney is lymphoma. Lymphoma can affect the appearance of the kidneys in a number of ways including renomegaly, abnormal shape, increased cortical echogenicity, the presence of hypoechoic masses and nodules and hypoechoic subcapsular tissue. The subcapsular tissue results in a hypoechoic band surrounding the renal cortex and is believed to represent regional subcapsular infiltrate with lymphosarcoma tissue. Although this is one of the more specific findings in lymphoma it can also be seen in other conditions such as FIP.

Polycystic kidney disease (PKD) is an inherited condition recognised most frequently in Persians and Persian-related cats. The condition is congenital and therefore the cysts are present at birth however they are miniscule and the condition is only detectable with ultrasound once the cat is at least several months old. Over time, these cysts grow in size gradually and insidiously replacing normal renal parenchyma. Cysts may also develop in the liver and pancreas. Ultrasonographically, the cysts are thin-walled, spherical, variably sized structures with anechoic, or less commonly, echogenic contents usually associated with distal acoustic enhancement. Not all cysts are associated with PKD. Occasional cysts may be present in the renal cortex of cats with chronic renal disease and are usually considered to be incidental findings.

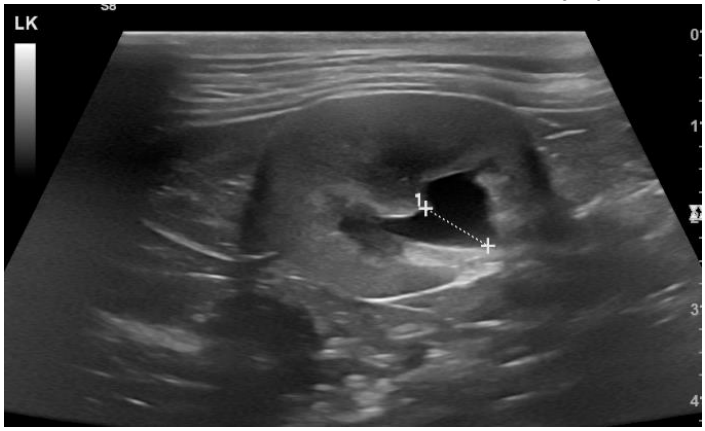


Renal Cysts in a cat with chronic renal insufficiency

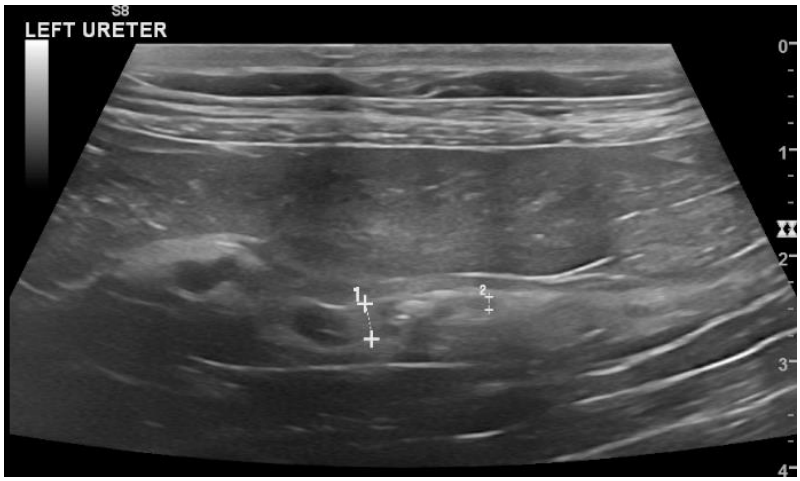
Renal infarcts are commonly identified during ultrasound of the feline kidney. An infarct represents a region of dead tissue that has been deprived of its blood supply. Infarcts may be classed as acute or chronic. Chronic infarcts are more commonly identified and are recognised by their classic hyperechoic wedge-shaped appearance in the renal cortex. The renal capsule may be slightly indented focally due to contraction of fibrous tissue. They are usually considered to be incidental findings. Acute infarcts are uncommon and present as a hypoechoic wedge-shaped region of renal cortex sometimes associated with focal bulging of the renal capsule due to tissue oedema.

The collecting System

The term pyelectasia is used to refer to mild to moderate non-obstructive dilation of the renal pelvis whereas the term hydronephrosis is typically reserved for dilation secondary to obstruction and can be severe. As previously mentioned, mild renal pelvic dilation (up to 3mm) can occur in cats with clinically normal renal function and especially cats undergoing diuresis for example due to diuretic or fluid administration. Cats with acute or chronic renal insufficiency may also have pyelectasia up to 7mm diameter due to the diuresis that can naturally accompany these conditions. Renal pelvic dilation up to 12mm diameter is suggestive or of either urine outflow obstruction or infection (pyelonephritis). In cats with pyelonephritis, the renal diverticuli may become enlarged, blunted and distorted and appear as fat finger-like projections that communicate with the renal pelvis on ultrasound. Urine within the renal pelvis should appear anechoic however, in some cases of pyelonephritis, the fluid becomes echogenic and a fluid-debris line may be apparent due to sedimentation of inflammatory cells (pyonephrosis – literal translation: pus in the renal pelvis). In acute pyelonephritis the kidney(s) may be enlarged whereas in chronic pyelonephritis the kidney is usually small, irregular, hyperechoic and has reduced corticomedullary definition depending on the severity of disease. There may also be free fluid in the retroperitoneal and/or peritoneal spaces associated with hyperechogenicity of the adjacent fat consistent with secondary retroperitoneal and peritoneal inflammation. This occurs due to exudate leakage from the inflamed kidney. When the renal pelvis becomes dilated by $\geq$13mm, this is highly suggestive of outflow obstruction. In severe hydronephrosis, pressure necrosis of renal parenchyma can result in a loss of renal tissue and nothing but a thin cortical rim surrounding the dilated renal pelvis. In cats, the most common cause of outflow obstruction is ureterolithiasis. Normal feline ureters are difficult to follow as their diameter is usually <1mm. When a ureterolith is present, the ureter proximal to the obstruction dilates (hydroureter) by a variable degree depending on the degree of obstruction. Distended ureters often become tortuous however they can usually easily be followed to the site of obstruction when they reach this stage. A dilated ureter may be differentiated from a blood vessel by its absence of flow on colour Doppler. Care should be taken to avoid mistaking the normal renal artery and vein, which enter the kidney at the renal hilus along with the ureter, as a dilated ureter through the use of Colour Doppler. Ureteroliths are identified by their echogenic interface and distal acoustic shadowing. Depending on the extent of obstruction, the ureter proximal to the ureterolith(s) is usually dilated whilst that distally is normal in diameter unless there are confounding issues such as ascending infection. The presence of hyperechoic fat surrounding the ureter is consistent with peri-ureteritis. In cats with ureterolithiasis, it is common for there to be more nephroliths present in the renal pelvis. It is important that these are identified since they may themselves pass into the ureter at a later date. Since dystrophic mineralisation (nephrocalcinosis) of the kidney has the same acoustic properties as nephroliths, differentiating between the two can be difficult and is not always possible.

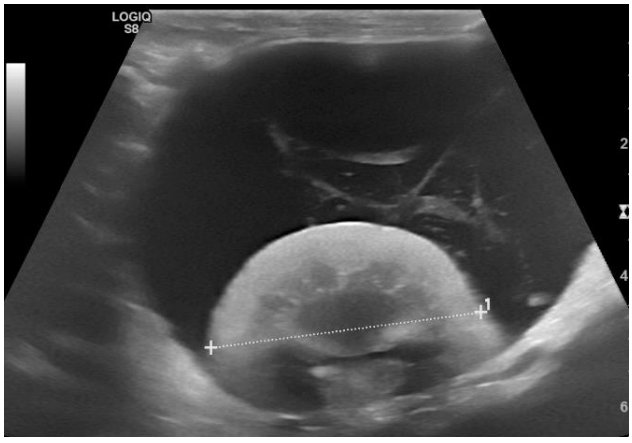


Pyelectasia



Obstructive ureterolithiasis

In some instances, fluid collects between the renal cortex and capsule. This is known as peri-nephric pseudocyst formation and older, male cats may be predisposed. The fluid is believed to be a transudate that accumulates between the renal cortex and capsule as a result of underlying parenchymal disease. Ultrasonographically, the kidney is surrounded by a large volume of fluid within the renal capsule. The fluid is usually anechoic to hypoechoic due to its cell-poor nature. Peri-nephric pseudocysts can contribute to abdominal discomfort and whilst drainage can help temporarily relieve this, it does not alter the progression of the underlying renal disease.



Perinephric Pseudocyst

Interventional Procedures:

Fine needle aspiration of the kidney can be safely performed under sedation or anaesthesia and may provide a diagnosis particularly in focal lesions or when lymphoma is suspected as this exfoliates cells well. It is much less helpful in cases of suspected glomerular disease and interstitial nephritis. FNA is best performed under ultrasound guidance rather than using a blind technique. A 23G needle usually works best and only the cortex should be sampled to avoid inadvertently damaging arcuate arteries at the cortiomedullary junction.

Urinary bladder

The urinary bladder is located within the caudoventral abdomen. The normal feline urinary bladder wall measures between 1.3mm and 1.7mm in thickness depending on the degree of distension (Finn-Bodner 1995). The bladder consists of four wall layers: the mucosa (hypoechoic), submucosa (hyperechoic), muscularis (hypoechoic) and serosa (hyperechoic). These layers are not as easy to identify with ultrasound as those of the gastrointestinal tract. The ureters enter the trigone region of the urinary bladder and at each entrance point, the ureteral papillae may be visible as small 'bumps' in the mucosa and should not be mistaken for mass lesions. Colour flow Doppler placed over the papillae may capture jets of urine as they are expelled through the papillae into the bladder lumen.

Urine is normally anechoic however in some cats, hyperechoic foci may be visible suspended within the lumen of the bladder. These represent lipid droplets and are considered incidental. Uroliths present as gravity-dependent hyperechoic interfaces usually associated with distal acoustic shadowing. The size of the acoustic shadow is related to the size of the urolith. The larger the urolith, the larger the acoustic shadow and vice versa. Some uroliths may be too small to create a shadow. When in doubt, increasing the frequency of the transducer and adjusting the focal zone to the level of the urolith can improve visibility of any acoustic shadow that may be present. The composition of the urolith (e.g. struvite, calcium oxalate, cysteine) has no bearing on the ultrasound appearance and therefore stone type cannot be determined on ultrasound.

Feline idiopathic cystitis is one of the more common indications for scanning the urinary bladder. In some cats, there may be no changes visible however in others, cystitis is recognised as thickening and sometimes reduced echogenicity (reflecting oedema) of bladder wall. Thickening is usually most marked at the cranioventral aspect of the bladder.

The main differential for bladder wall thickening is neoplasia. Neoplasia of the urinary bladder is much less common in cats compared with dogs however transitional cell carcinoma is the most common malignancy of the bladder in both species. Transitional cell carcinoma (TCC) has a predilection for the trigone region and dorsal wall of the urinary bladder although it can occur anywhere, including the cranial pole of the bladder. TCC typically appears as a broad-based sessile heterogenous mass which may be mineralised. Whenever neoplasia is suspected, it is important to assess the medial iliac lymph nodes which drain this region.

Cystocentesis is a routine procedure that is generally well tolerated and may be performed blind or under ultrasound guidance, the latter being particularly helpful when the urinary bladder is small. I use a 23-gauge 1-inch needle and either a 5ml or 10ml syringe. Clipping of the fur is not always necessary (although very often it is clipped anyway following abdominal ultrasound) and surgical spirit should be applied to the area. My personal preference is to have the cat in either dorsal recumbency or right lateral recumbency with the left leg elevated. Placing the cat on a deep vet bed is also more comfortable for the cat and they are more likely to have a relaxed abdomen which makes the procedure much easier. It is important that the cat is adequately restrained either physically or chemically. Chemical restraint is not usually necessary unless the cat is particularly fractious although much of the time, the procedure is carried out on cats that have already been sedated for abdominal ultrasound and this is usually the ideal time to obtain a sample by cystocentesis. If the cat is conscious, then ideally two assistants should be involved in restraining the cat, one holding the forelimbs and head and the second person holding the hind limbs. The cat should ideally be as relaxed as possible and having two assistants means that one person can concentrate on the head end and distract the cat by rubbing its head and/or talking to it whilst the procedure takes place.

I am right-handed and hold the transducer in my right hand and the needle and syringe in my left hand. The needle should be visible at all times and this is achieved by keeping the needle aligned with the plane of the ultrasound beam. Care should be taken in smaller bladders not to penetrate the aorta, which lies just dorsal to the urinary bladder can inadvertently be lacerated potentially leading to life-threatening haemorrhage. Complications are rare and include bruising, haemorrhage, urine leakage and bladder rupture (more likely in cats with urethral obstruction). Very rarely, cystocentesis can trigger a vasovagal reaction which can be profound and dramatic and occurs immediately following the procedure. Reported reactions include bradycardia, hypersalivation, tachypnoea, open-mouth breathing, vomiting, urination and weakness. Spontaneous recovery within minutes is expected within a few minutes with supportive care (oxygen therapy and observation).

Adrenal Glands

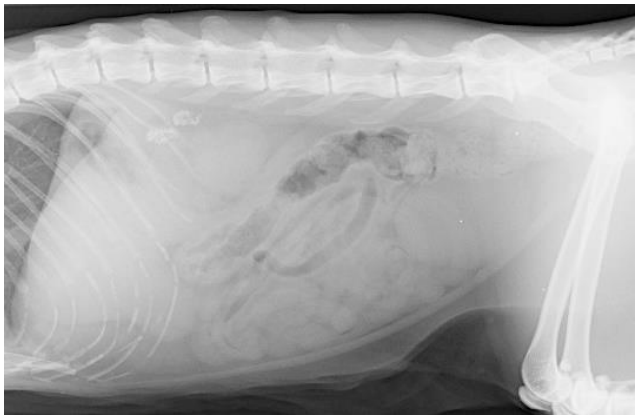
The adrenal glands are retroperitoneal organs that are located medial to each kidney. There are relatively few indications to image the adrenal glands in cats however it is important to be able to recognise them. To locate the left adrenal gland, find the left kidney and start by scanning the area medial to the left kidney and lateral to the aorta. The adrenal gland can usually be identified in an area bordered by the left renal artery caudally, the cranial mesenteric and coeliac arteries cranially, the kidney laterally and the aorta medially. The left renal artery exits the aorta and forms a characteristic hook-shape as it travels towards the kidney. Cranial to this, two vessels exit the aorta in close association with each other. These are the coeliac artery (the more cranial vessel of the two) and the cranial mesenteric vessel. Most of the time the left adrenal gland can usually be located somewhere between the coeliac/cranial mesenteric vessels cranially and the left renal artery caudally. The situation is similar to locate the right adrenal gland except that this gland is often found in close association with the caudal vena cava rather than the aorta. Therefore, the area medial to the right kidney and lateral to the caudal vena cava should be scanned. It should also be noted however that the adrenal glands in cats can be more variable in their position relative to the kidney and are sometimes located just cranial to the kidney and coeliac artery. Normal feline adrenal glands are ovoid in shape, well-defined and mildly hypoechoic relative to surrounding fat. If imaged with a high-frequency linear transducer the adrenal cortex will appear hypoechoic relative to a hyperechoic medulla (the opposite of the normal kidney). Normal adrenal gland size in cats is around 3.5mm to 4.5mm in width (some texts state slightly outside this range) and around 1cm in length.

Adrenal mineralisation is a common finding in older cats and at present, this is considered to be incidental.

The Medial Iliac Lymph Nodes

The medial iliac lymph nodes (MILNS) are located at the level of the aortic bifurcation. Ventral to the caudal lumbar spine around the level of the sixth lumbar vertebra, the aorta divides into the left and right external iliac arteries and median sacral artery. The left and right MILNs are located either side of the aorta where it branches into the external iliac arteries. The left and right deep circumflex iliac arteries branch perpendicularly from the aorta just cranial to MILNs and can also be used as landmarks.

Mineralised adrenal glands in a cat:



Mineralised adrenal gland on ultrasound.