Ultrasound imaging has become widely accepted as an important diagnostic tool for imaging the gastrointestinal tract in animals. Anticipated artifacts created by gas and fecal material were initially thought to significantly limit or exclude examination of the gastrointestinal tract by ultrasound. In actuality, the artifacts, though present and at times obstructive, rarely significantly interfere with the entire examination. There has been marked improvement in technology with higher resolution (12-18 MHz and higher) transducers and more affordable equipment currently available. This combined with endosonography and Doppler ultrasound has resulted in more thorough imaging of the intestinal tract with improved critical evaluation and understanding of changes from diseases affecting the gastrointestinal tract.

Ultrasound uses sound to reflect from the tissue boundaries within the body to form an image that we can recognize and interpret. It is noninvasive and has no known significant biological risk at diagnostic frequencies (1-25 MHz). It is particularly useful in evaluating the intestinal wall, the luminal contents, function evidenced by peristalsis, and in interrogating the surrounding organs such as the peritoneum, pancreas, liver and lymph nodes. Ultrasound is also useful in guiding needle placement for either an aspirate or biopsy of a detected abnormality. Intestinal ultrasound provides additional and complementary information to other diagnostic modalities (survey radiographs, computerized tomography, nuclear medicine, magnetic resonance imaging, contrast radiography). With recent improvement in technology and knowledge, there has been advancement in the diagnosis of diseases affecting the intestinal tract of cats. But with the improvement in technology and knowledge, there are new questions that arise as to the meaning of the findings and there remains a great deal to be learned regarding the intestinal tract of the cat. It is especially important to correlate the ultrasound findings with the history, clinical findings, laboratory results and ultimately with cytopathology and histopathology. Ultrasound imaging has now become such an integral part of the diagnostic work-up of small animals with gastrointestinal signs that there has been marked reduction in radiographic contrast procedures such as upper GI studies. It is faster, more cost effective and often provides as much or more information than the other diagnostic modalities.

**Method of evaluation**

To achieve the best image quality, hair should be removed from skin of the imaging area in most cats via a surgical clipping blade (40). The area clipped usually encompasses a rectangular area extending from the epaxial muscles in the dorsocranial abdomen (usually 8-9th ribs) to the caudal abdomen just in front of the pelvic limbs and ventrally to the mid line on both sides of the animal. A concerted attempt is made to keep the margins of the clipped area neat and straight as this appearance is often noticed and important to the owner. Mammary papilla may be obscured by the surrounding hair and may be at risk for trauma from the clipper blades from those less experienced in clipping. The area clipped will be more extensive when imaging from a lateral position compared to the dorsal recumbent position. Commercially available ultrasound water soluble gel is used to act as an interface between the skin and the transducer. If the animal has thin hair, wetting the hair with water and alcohol may be done in lieu of cutting the hair. Alcohol may also be used to clean the skin of animals with dry, dirty or scaly skin and this application of alcohol often results in reduction in the amount of gel used and an improved image quality.

**Normal anatomy**

Examination of the entire intestinal tract is typically a part of each sonographic study of the abdomen. The examination includes interrogation of the specific sections of the intestine (esophagus, stomach, duodenum, jejunum, ileum and colon) noting the wall thickness, distinction of the wall layers, the luminal contents in each section, motility and vascular integrity.

The wall layers of the intestine include 5 layers with an alternating hyperechoic and hyperechoic appearance. The 3 hyperechoic layers (the “S” layers are serosal, submucosa and surface of the mucosa) and 2 hypoechoic layers (the “M” layers are the muscularis and mucosal layers). The wall thickness is in part related to degree of distinction of the loop of intestine. It is mildly thinner the more distended it becomes. A contraction during normal peristaltic activity does mildly affect the width of the intestinal wall and the width of specific layers may momentarily change with contractions. The intestinal tract is dynamic and contractions cause a shortening of the length of the loop of intestine with an increased width of the muscular and mucosal layers in the contracted area compared to adjacent dilated segment. It is important to be careful and consistent in placing the cursors for wall measurement. The stomach has characteristic rugal folds that radiate towards the center and is often empty. The stomach wall varies from 1.7 to 2.8 mm in width. It is important to make sure that a rugal fold or an oblique cut is not being measured and giving an erroneous thickened measurement especially on an empty stomach. It is easiest and most accurate to measure the wall when a small amount of fluid is present within the stomach lumen. This may require orally administering water if there is a question about the wall thickness. The duodenum and jejunum are usually 2.3 to 2.8 mm in width. The ileum is more difficult to accurately measure the wall due to the contracted “wagon

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Gastrointestinal disorders

Disorders involving the gastrointestinal tract may be divided into those involving the lumen, the wall or those arising outside the intestinal wall. A final diagnosis or differential diagnosis involves correlating the abnormal sonographic findings to the history and laboratory results and may require an aspirate or histopathology or cytology.

Luminal changes

The luminal abnormalities typically are due to abnormal contents such as a foreign body or an intussusception or abnormal distention of a segment of intestine that may indicate an obstruction. This dilation may be combined with specific mural changes that may be due to a linear foreign body, or an infiltrative disease such as neoplasia that extends into the lumen and affects passage of contents.

Obstruction

The stomach and small intestine are often empty of contents and it is atypical for the normal feline intestinal tract to contain much fluid or gas. If distension of the lumen is seen, then questioning when a meal was ingested or if gastrointestinal signs are present will often help to determine the significance of the finding. If there remains a question of the significance, and the patient is stable, fasting the patient for 12 hours and repeating the study to ascertain if the material is still present may be warranted. If the stomach is distended, this may be due to a recent meal, a motility problem or possibly due to an outflow obstruction. Careful evaluation of the antrum and pylorus and proximal duodenum for the cause is warranted. When luminal obstruction occurs, the intestinal tract will often be distended and filled with motile hypoechoic fluid and possibly gas oral to the obstruction. The cause of the obstruction may be intraluminal, mural or less often extraluminal. Just because the distended intestinal tract contains gas evidenced on the radiographs does not preclude the utility of abdominal ultrasound in identifying the abnormality. If there is a high obstruction within the duodenum, vomiting may but not always result in a decrease in the distension of the lumen. Segments of small intestine distal to the obstruction are usually of a normal size. It is useful to locate the dilated segments and follow them to the point of the obstruction. Try to determine the location of the bowel segment obstructed and evaluate the lumen for an intraluminal foreign body, mass with wall thickening or an extra luminal component. If it is the ileum, the entire small intestine may be affected and dilated. If it is the jejunum or duodenum, the segments distal should be normal in size. Locating the ileum is useful to make sure that it is due to an obstructive process and not due to a metabolic cause. With pancreatic insufficiency, malabsorption syndrome, or some inflammatory diseases, the intestine may be markedly distended throughout without normal-sized small intestine detected. If the entire small intestine is dilated
including the ileum and there is no mass or intussusception at the ileocolic junction, then the luminal dilation is unlikely to be due to a mechanical obstruction.

**Foreign bodies** are a frequent cause of luminal obstruction. The foreign body will vary in appearance depending on their physical make up. The shape and appearance of the foreign body may allow identification of the actual foreign body. Fluid in the lumen surrounding and outlining a margin the foreign body may facilitate its identification due to a characteristic recognizable geometric shape

Some foreign bodies are very characteristic in appearance and make identification simple. Other foreign bodies such as cloth are highly attenuating and may have a hyperechoic surface. Not all foreign bodies are inciting a clinical problem in the animal. Grass, rocks, and other materials may have been ingested especially if the animal has an intestinal problem. They may not result in clinical signs but be identified on the ultrasound exam. Parasites such as ascarids may be identified as mobile, tubular, undulating, often tangled foreign bodies within the GI tract. Determining if foreign objects are incidental will be important in the management of the patient. This may be accomplished by examining the relevant historical signs of intestinal disease, determining if the foreign object is causing an obstruction or resulting in a plication of the intestine. Foreign bodies such as a hair ball (gastric or enteric trichobezoars) often have an irregular poorly defined margin, are heterogeneous, have a hyperechoic surface and have significant attenuation and shadowing. This may be clinically relevant if the history supports accurate historic fasting for at least 12 hours. Correlating the ultrasound findings with abdominal radiographs may also assist in identifying the significance of specific foreign bodies such as an eroding penny resulting in zinc toxicity. Determining the kind of foreign body present is often a delightful mental challenge that is quickly rewarded by the removal and identification of the object.

**Linear foreign body**

A foreign body that is linear in shape may be found in the lumen of the gastrointestinal tract and may be due to ingested material such as hair or grass. This material has a linear appearance but is not embedded in the wall, the ends may be located (not anchored in the stomach), and the foreign object does not have a taunt appearance and is not on the mesenteric side of the small intestine with a placation or gathered appearance to the adjacent segment of intestine. The appearance of a true linear foreign body will depend on the type of material present. Linear foreign bodies have a place of secured attachment such as around the tongue or trapped within the stomach. The remainder progresses aborally downstream and becomes embedded in the wall of the intestine. With peristalsis and segmental contractions, gathering of the intestine on the string as it embeds in the wall occurs. Typically, the foreign body is eccentrically located on the mesenteric side of the bowel and is taunt as it is anchored with the ends not free in the lumen. It is often partially imbedded in the wall. The bowel may be plicated and thickened as the string erodes into the wall. Peritoneal fluid may be present. Free air in the peritoneal cavity often indicates perforation. Panty hose, cloth-like material, plastic or rubber products will attenuate the beam and often have shadowing similar to feces in the colon. This can be more challenging to identify compared to string (like dental floss) as it may be incorrectly assumed to represent feces in the colon. Making sure that the segment of intestine is the small intestine and not the colon is needed. The colon should have a thinner wall, have ileum entering it, and exit through the pelvic canal. If necessary, the colon can be identified as it courses through the pelvic canal. It is then followed cranially to determine if it communicates with the questionable segment of intestine. When a linear foreign body is identified, the wall should be closely examined for thickening, ulceration or perforation. Intussusceptions may occur in conjunction with a linear foreign object due to the abnormal motility and constriction afforded by the plicated segment of intestine.

**Intussusception**

An intussusception occurs when one segment invaginates into an adjacent segment. The intussusception is made of the double walls of the outer intussuscipiens and the inner loop of invaginated intestine, the intussusceptum. The most frequent type is an ileocolic intussusception. Other types include enterenteric or less commonly, cecocolic, gastroesophageal or duodenogastric. The classic sonographic image is a transverse plane through the intussusception. The double concentric hyperechoic rings that form the thicker outer wall surrounding a central hyperechoic core with a cross section of an eccentrically located loop of small intestine within the lumen is classic for the diagnosis of an intussusception. The intussuscipiens is often thickened, and hypoechoic. The intussusceptum located within the cross sectional view is the transverse segment of intestine eccentrically located within the lumen of the intussuscipiens. This usually appears as a normal empty loop of intestine. The eccentrically positioned hyperechoic material is the mesentry attached to the mesenteric border of the intussuscepted segment of intestine and it acts as a mass resulting in displacement of that segment of intestine to the opposite wall. The longitudinal plane shows multiple layers of the two bowel segments telescoped within each other. The thicker layered outer wall is the combined wall of both the intussusceptum and intussuscipiens. The leading edge of the intussusceptum may be identified at the distal end of the intussusception. In cats, identification of enlarged lymph nodes or thickened GI wall may be seen and indicate the initiating cause of the intussusception such as an adjacent tumor of the intestine or enlarged lymph nodes. The mesentry should be uniform except for small vessels. Enlarged lymph nodes or masses may be seen within the mesentery intussuscepted and may give an indication of the cause. There may be fluid present that may be due to hemorrhage or a chronic intussusception and lymphatic obstruction and cystic formations or vascular compromise. The
intussusceptum should be empty of internal contents. A hyperechoic internal structure may indicate a linear foreign body was the inciting cause. This may be followed beyond the intussusception where plicated intestine may be found.

**Mural changes**

This is an area that is complicated and challenging with many diseases and overlapping appearances. A lot of work to learn more is currently underway in this area and a great deal still needs to be done to increase our knowledge base. We know the normal size of the wall of the intestine and the 5 distinct wall layers. We know that an infiltrative disease of what ever kind may affect the wall and cause thickening of one or all of the layers and that there may be disruption of the layers with an indistinct margin between the layers. We use this information combined with the history and abnormalities affecting other organs to attempt to determine the underlying disease process. Some diseases are unique and specific and easier to diagnose. The ultrasound appearance does not provide a histologic diagnosis but it does give hints. It does provide morphologic information. It may indicate the location and extent of involvement. An aspiration or biopsy is often necessary for confirmation of the final etiology. Wall thickening is the most consistent sonographic finding of mural diseases. Thickening of the wall, presence or absence of retention of the wall layers and echogenicity are useful aids in evaluating the GI wall. A clear distinction between diffuse change vs focal change is frequently helpful in ranking the differential diagnosis. Generalized thickening is often seen with inflammatory disorders and localized and asymmetrical thickening with disruption of wall layers is an indication of a potentially serious infiltrative process. Unfortunately, the severity of thickening is not always a parameter that can distinguish inflammatory disease from neoplastic disease.

Sonographic appearance of inflammation varies with the cause, duration, extent of involvement and secondary involvement of other organs. It can be accompanied by normal or increased wall thickness.

A general rule to apply is that generalized, symmetric wall thickening without loss of the wall layers is often associated with inflammation possibly from IBD, mycobacterium, FIP or Histoplasmosis. A challenge is sometimes differentiating between lymphosarcoma (small cell) and IBD or other causes for an inflammatory process. Asymmetric wall thickening with loss of the layers is typical of a more aggressive process such as neoplasia. A change in the echogenicity of the wall layers may occur with both but is seen more with neoplasia. Spasticity may accompany an irritated segment of intestine or one with vascular compromise. Most neoplasms create large mass effects, are hypoechoic and there is disruption of the wall layers. Disruption of the mucosal surface often denotes an aggressive process. The focal infiltrative disease may distort the wall and protrude into and compromise the lumen and may also protrude beyond the serosal surface. The appearance will vary depending on the stage of advancement of disease and tumor type. R rigidity may be evaluated by the peristaltic waves that progress through a specific segment. Concomitant obstruction may be present. Abscesses, granulomas or tumors may result in this appearance. Wall thickness either symmetric or asymmetric and localized or generalized may help but often a biopsy is needed to ascertain cell type. Success of aspiration of the GI wall may be unrewarding. It is more successful in exfoliating lymphosarcoma and malignant diseases especially masses >2 cm. Aspiration of a regional enlarged lymph node may be more helpful. The more destructive the process and the more other organs are involved, the more likely that neoplasia is the root problem. Ulcers identified as gas filled craters surrounding thickened wall are often associated with tumors but may be seen secondary to non-inflammatory drugs.
Musculoskeletal imaging with ultrasound has been used extensively in the equine. It is often used in the diagnosis of human musculoskeletal diseases. It has started to become very useful in the dogs and cats.

This session will focus on specific joints and diseases affecting the musculoskeletal system. The shoulder including the appearance of OCD affecting the humeral head and the normal and abnormal appearance of the tendons and ligaments around the shoulder joint including the bicipital groove will be discussed. The calcaneal tendon and also the stifle joint including specific changes from abnormalities including trauma affecting each area will be discussed. In addition, the iliopsoas muscle, other muscles and body wall masses will be presented with instruction on how to find and identify the structures and how disease will secondarily affect this normal appearance. Examples of the appearance of neoplasia affecting bones, joints and the soft tissue will be presented. The unique appearance of different kinds will be discussed. Examples of normal nerves and the appearance of nerve sheath tumors will be shown. Tips for aspirating cells from some of these challenging bony lesions will be given.

This diagnostic tool is a useful technique to add to your radiographic imaging.
A radiographic interpretation may state “compatible with the age of the patient”. There are changes within the thorax that are commonly identified in our older canine population. Some of these represent changes within the structure of the lung, or skeleton. They may not be related to any clinical evidence for significance. They mimic significant disease or mask disease. This paper will look first at some of the changes commonly seen that are considered not significant. The last part of the paper will include diseases more commonly identified in the older population. The aged patient usually would include patients 6-7 years or greater.

The lung is often an area that changes with age. It is an especially challenging area to interpret. As a study in 2000 elderly human patients described the “senile lung” as a spongy or lacy pattern of the lung fields associated with increased peripheral lung markings and an increased contrast of pulmonary markings”. Changes within the lungs may involve the distal airways, the interstitial space, the pleura, and the cardiovascular structures. When an alveolar pattern is present, this is more commonly associated with a specific disease and less often associated with simply the aging of the lung.

Bronchial pattern
Thickening and mineralization of the trachea and distal airways is often seen to increase the visibility of the walls of these structures. This is presumed to be due to calcification within the walls. There are more tramlines and “donuts” seen within the lung especially near the hilus. The tracheal rings are mineralized and can be traced into the main stem bronchi and into the parenchyma. This appearance may be also associated with diseases such as Cushing’s disease. The patients usually are not coughing. Dogs especially the small breed dogs such as the Pomeranian or Poodle may have collapsing of the trachea and main stem bronchi. There is often coughing with this disease process. Fluoroscopic evaluation is often warranted. With chronic bronchial disease there may be bronchiectasis with focal widening of the bronchial lumen. There may be distal alveolar disease due to the ineffective mucociliary apparatus. Dogs chronically exposed to noxious material including smoke may have thickened bronchial walls and an increased unstructured interstitial pattern.

Vascular pattern
Mineralization of the walls of vessels (atherosclerosis) may be secondary to hypothyroidism, vascular injury (possibly from heart worms or other PTE causes including Cushing’s disease). There may be mineralization of the aortic valves. The primary cause for a change in the appearance of the pulmonary vessels is due to cardiac disease often observed in the older population. This includes heart worms (enlarged pulmonary arteries), chronic valvular disease (enlarged pulmonary veins), and cardiomyopathy (enlarged pulmonary veins and sometimes the arteries). End-on views of the vessels may mimic pulmonary metastatic disease. A decreased size to the vessels often is due to hypovolemia (blood loss, dehydration, Addison’s disease). It may be seen in the aged population from other diseases but is not generally a true aging finding.

Interstitial pattern
This pattern is the category most often affected by aging changes. This pattern can be divided into the unstructured appearance and the structured appearance (nodules, masses). The unstructured pattern is most often seen. Often the older patient has an overabundance of body wall fat. This adds to the overall opacity to the lung. The patient may not take deep inspiratory breaths and thus the lungs are less aerated and this adds to the overall opacity to the lungs. In addition there are fine, nonvascular linear markings that are associated with pleural thickening. This is especially evidenced between the right middle and accessory/caudal lung lobes. These do not branch as would occur with the bronchial or vascular structures. They are often seen in specific locations. Pleural fibrosis may occur and may be seen as pleural scars (plate atelectasis) or more diffuse areas of pleural thickening. There is more fibrous connective tissue present. The alveolar walls and ducts may thicken with fibrous connective tissue. This may also be seen sub pleural. There may be an increased amount of cuboidal and squamous epithelium and hypertrophied alveolar lining cells. Dogs with chronic mitral insufficiency had prominent and thickened alveolar walls.

A structured interstitial pattern may be found in the older patients. This is often described based on size and opacity of the nodules. They range from reticular nodular, military nodular to nodular and then to masses. The opacity may be soft tissue or mineralized. They may be solid or cavitated. Usually with benign age related changes the structured changes are small nodules. This may occur in approximately 10% of the older dog population examined in one report. If mineralized they usually represent metaplasia or heterotopic bone. They are usually not clinically important but if extensive then it could be clinically relevant. Alveolar microlithiasis of the lungs from Cushing’s disease has been reported. The lungs are noncompliant and do not collapse when removed from the patient. Discrete foci of bone have been described histologically with heterotopic bone. This has been hypothesized to involve transformation of fibroblasts into osteoblasts with the formation of dystrophic mineralization. This is often at the periphery of the lung.
especially in Collies. They are often small measuring 1-3 mm in width. If smaller they may not be discerned as a nodule but merely increase the overall opacity to the lungs. They are separated from vessels because of the tail of the vessel and the size of the structure based on where it is located in the lung. The closer to the hilus the larger it is. It should be the same size as the adjacent vessels in that part of the lung if it is an end on vessel. The changes in the lungs over time may be associated with subclinical disease, exposure to pollutants or noxious material inhaled.

**Specific diseases**
Diseases that occur more frequently in the older patient population is varied.

**Neoplasia** is a frequent disease in the older population is a common reason to image the thorax. Typically, neoplasia affects the interstitial space and is manifested by a structured pattern. Metastatic disease is often soft tissue in opacity and multiple. Some types of metastatic tumor may have cavitated centers. These are usually from tumors that are glandular. Mineralized metastatic lesions occur but are uncommon. Primary lung tumors are often singular and large. They may be mineralized and cavitated. Lymphoma may have more of a reticular nodular pattern as the lymphatics are distended with the neoplastic infiltrate. The lymph nodes (sternal, cranial mediastinal and hilar) are often enlarged. There may be rib tumors (primary or metastatic) overlying the lungs that may have an extra pleural sign, pleural effusion and metastasis.

**Heart disease** is a common abnormality in the canine population. Chronic valvular, heart worms and cardiomyopathy are the most frequently encountered. There are specific changes identified in the size of the heart and the specific chamber affected. Noting if it is right sided vs. left sided is important in determining the underlying disease. It is important to determine if heart failure (right or left) is present.

**Pleural disease** is usually manifested by either air fluid or a mass in the pleural space. The lungs usually respond by decreasing in size and increasing in opacity. This in part is due to less air in the lungs and the overlying soft tissue opacity overlying the lungs. Fluid in the pleural space may be categorized as blood, pus or water. It may be due to hemorrhage from a clotting disorder, trauma, and rupture of a mass. It may be due to purulent material from trauma, foreign body, and septic pleuritis. Water is often due to heart failure or chyle from lymphatic disruption. Fluid or air will cause separation of the lungs from the thoracic wall and a change in opacity. The lungs contain vessels that go to the periphery. When a pneumothorax or pleural effusion causes the lungs to not extend to the periphery, then the vessels also do not go the full extent of the thoracic cavity.

**Mediastinal disease** is usually manifested by a change in size, shape and opacity of the mediastinal area. The esophagus if dilated will cause the trachea to be displaced ventrally. It is often dilated with fluid and gas. Masses in the cranial mediastinum often cause a widening of the mediastinum. This may displace the trachea and heart and lungs. Structures within the mediastinum may be affected. This included the lymph nodes, the thymus, vessels. Cysts may also cause a mass effect. A heart based mass usually dorsally displaces the distal trachea and silhouettes with the heart. A thymoma often is more ventral and close to the heart. Lymphoma often affects multiple lymphocenters such as the sternal, cranial mediastinal and hilar. A pneumomediastinum may come from a patient with interstitial disease or trauma to the esophagus, neck or trachea. The structures within the mediastinum are better imaged than normal.
Ultrasound Imaging of the Pancreas in the Dog and Cat

Kathy Spaulding, DVM, DACVR
Texas A&M University
College Station, TX

Imaging of the pancreas by radiography is limited by the effect of pancreatic disease has on the size of the pancreas, the production of fluid and impact on surrounding structures. The changes seen are often subtle and nonspecific and thus a diagnosis from a radiograph is often challenging. The advent of real-time ultrasound has made visualization of the pancreas a reality even in normal patients. However, even though the pancreas may be seen with ultrasound, the differential can still be challenging especially with cats. The pancreas is typically a challenging organ to image. As imaging equipment has improved, the ability to recognize the pancreas has markedly improved. It is very important to know normal landmarks to find the pancreas. Things that interfere with good examination include; a postprandial exam, excessive gas, and an uncooperative patient with a tense abdomen. Lack of abnormal sonographic findings does not totally eliminate pancreatic disease as a cause of clinical signs. The major challenges are to distinguish the normal pancreas; to distinguish this from abnormal; to differentiate between pancreatitis and malignant neoplasms and to separate pseudocysts from abscesses.

Disorders involving the feline pancreas in the past have been considered uncommon. But recent information suggests that pancreatitis is more common. This is a challenging disease ante mortem. Clinical signs may be mild or nonspecific. Blood work including chemistry, pancreatic enzymes are non-sensitive. Radiography is insensitive. This leaves one with ultrasound imaging. It is currently the imaging modality of choice in the cat and the dog.

Normal anatomic location
The pancreas may be located by identifying its parenchymal architecture and anatomic landmarks that surround the organ. The normal pancreas is hard to see and may not be seen if using a transducer lower than a 7.5 MHz Ideally the transducer should be a 10 -13 MHz or higher. The echogenicity of the pancreas is isoechoic to slightly hyperechoic to the caudate lobe of the liver and slightly hyperechoic to the spleen and hyperechoic to the surrounding mesenteric fat. The mean thickness of the pancreas in the cat was as follows: right pancreatic lobe (4.5 mm range 2.8-5.9), body (6.6 range 4.7-9.5mm) and left side (5.4 range 3.4-9.0 mm). The pancreatic duct had a mean thickness of 0.8 mm =range 0.5-1.3 mm). The gastric lymph node was identified in 6/20 cats. 10 mm-6.0 mm. They found not to include; a postprandial exam, excessive gas, and an uncooperative patient with a tense abdomen. Lack of abnormal sonographic findings does not totally eliminate pancreatic disease as a cause of clinical signs. The major challenges are to distinguish the normal pancreas; to distinguish this from abnormal; to differentiate between pancreatitis and malignant neoplasms and to separate pseudocysts from abscesses.

Different authors have described different methods to find the pancreas. The pancreas consists of the left limb, body and right limb. To locate the left pancreas, place the patient in a right lateral decubital position and image the left dorsocranial quadrant of the abdomen. A triangle of organs is useful in finding the left lobe. Locate the spleen in the near field, the greater curvature of the stomach cranially and cranial pole of the left kidney caudally. The left lobe will extend laterally to just medial to the spleen. The left lobe of the pancreas is located deep or medial to the spleen and caudal to the splenic vein. You may need to fan the region to see this structure. The tip of the left limb of the pancreas is larger than the rest of the pancreas and this is often an area that is affected by pancreatitis. In cats the entire pancreas can be imaged from this side. A long gray scale and high resolution are needed to see the subtle pancreas. The normal pancreas is only slightly different in echogenicity from the surrounding fat. It is best seen in small, young patients that image well. If the animal is fat or aged, then the increased amount of fat within the gland will increase the echogenicity and it will be difficult to distinguish from the surrounding fat. Often, the vessels within the pancreas and the pancreatic duct are seen. The right lobe and the body of the pancreas are best seen from the right side of the dog but are well delineated in the cat from either side. The landmarks for the body and right limb include the portal vein, the duodenum, the right kidney and stomach. The body of the pancreas is best seen from the right side with the transducer positioned parallel to the ~10-11 ribs just behind the liver. To help to locate the pancreas several techniques may be used. Find the mid abdominal aorta and caudal vena cava; slide the transducer ventrally while looking for a branching vessel (the portal vein confluence from the jejunal veins). Follow the portal vein cranially. A branch that comes toward the transducer (laterocranially) is the pancreaticoduodenal vein. Follow this vessel. It will point to the pancreas. While in the mid abdomen, look for a segment of intestine coursing in a cranio-caudal direction. It should be straight and then in the mid to caudal abdomen curve medially. If you follow this intestine cranially, it will join the stomach. This is the duodenum. Between the pancreaticoduodenal vein and the duodenum lives the pancreas. If you look at the duodenum in cross section, the pancreas will be located on the mesenteric side or medial and dorsal to the duodenum. The caudal vena cava is dorsal and medial and is not usually seen from this scanning plane. The right kidney is dorsal and lateral. Remember that the right lobe lies in the meso-duodenum dorsomedial to the descending duodenum, ventral to the right kidney and ventrolateral to the portal vein. The body of the pancreas is located between the right lobe and the larger left lobe (in the cat). It is found caudal to the pylorus of the stomach, craniomedial to the right kidney, ventral to the portal vein. The vessels within the right lobe include the cranial and caudal pancreaticoduodenal veins. The cranial vessel empties into the gastroduodenal vein which courses into the portal vein. The caudal vessel joins the cranial mesenteric vein. The vein in the left lobe empties into the splenic vein. Using these landmarks and relationships, the pancreas may be imaged...
either from the ventrodorsal position or the recumbent lateral position. Usually, an animal with pancreatitis is less painful when viewed in a lateral position. In addition, if the animal vomits readily when pressure is applied to the abdomen, then the lateral position is safer than a dorsal recumbent position. The proximal flexure of the duodenum may be traced into the pylorus of the stomach. The bile duct may be traced to the papilla where it empties into the duodenum. In the cat the bile duct and the pancreatic duct join in the cistern of Oder before entering the duodenum at the sphincter of Odi. The pancreas is located medial and dorsal to the duodenum. The right kidney and duodenum in a transverse view is a useful landmark to locate the right limb of the pancreas. The gastroduodenal and craniopancreaticoduodenal veins are useful landmarks to help locate the pancreas. The normal pancreas is mildly hypoechoic relative to the surrounding fat. In younger animals, it is frequently more hypoechoic and easier to image. In older animals, it may become more difficult to see as more atrophy has occurred.

**Pancreatic diseases**

Typical diseases involving the pancreas are usually related to inflammation or neoplasia.

**Pancreatitis**

This can be challenging in the cat as there may be no, minimal or significant sonographic changes apparent and the animal still have pancreatitis. The sonographic appearance will vary depending on the severity and duration of disease. The entire pancreas, the adjacent duodenum, the stomach, the biliary tract and peripancreatic tissue all should be included in the exam of the pancreas. Ultrasound findings may be negative in the milder forms of acute pancreatitis. Mild forms may have only an interstitial edema without involvement of the peripancreatic inflammation or fat necrosis. Severe cases have fat necrosis, parenchymal necrosis, hemorrhage and peripancreatic inflammatory changes. These typically sonographically will have varying degrees of hypoechogeticity. The pancreas will become increasingly more hypoechoic relative to the liver and increase in size. The pancreas may appear inhomogeneous. Fluid filled pseudocysts or abscesses may be present. The pancreatic duct may be enlarged. But this has been found to be larger in our older population of cats normally. Focal peritoneal fluid and hyperechoic peripancreatic fat are features seen with pancreatitis. If multiple incidences occur, fibrosis and calcification may result and the pancreas will increase in echogenicity. Pseudocysts and abscesses both may form as a consequence of the pancreatitis. The term pseudocysts should be reserved for an accumulation of fluid that persists for several weeks. Often with pancreatitis, the duodenal wall will be thickened and the segment of bowel will appear spastic. The bile duct may enlarge due to an obstruction or partial obstruction. Beware that an enlarged duct does not necessarily mean it is obstructed. In cats with pancreatitis, they may also have hepatic lipidosis and inflammatory bowel disease. The bile duct may be mildly dilated and tortuous in cats with hepatic lipidosis and not be obstructed. With pancreatitis, the duct may become obstructed due to the surrounding inflammation. However, the obstruction may resolve and the duct remains dilated. Compare the ultrasound findings with the clinical picture. A sonographically observed dilated duct along with the appropriate clinical picture is indicative of an obstructed duct. Serial sonograms are important to follow pancreatic lesions. The surrounding fat is hyperechoic due to saponification of fat. The animals frequently have been vomiting and often the stomach is empty. Peritoneal effusion is frequent present in more severe cases but may not be as evident in cats with interstitial changes and milder pancreatitis. Chronic pancreatitis is often more of a sonographic challenge Chronic pancreatitis is more difficult to image as atrophy, scarring with possible mineralization in some areas and inflammation in others may make diagnosis more challenging. In the cat, hepatic lipidosis may accompany pancreatitis. It is often more difficult to recognize pancreatitis in the cat. An abscess within the pancreas is important to try to ascertain as this may be a surgical emergency. An abscess may be difficult to tell from a pseudocyst. The clinical history, the laboratory data and course of disease are often used to help sort this out. Usually the wall of an abscess is thick and irregular. The echogenicity of the fluid contents may vary. Gas may be present. Fibrous connective tissue proliferates. The sonographic findings may include the inability to see the pancreas because the scar tissue resulted in a similar echogenicity as the surrounding fat. The echotexture may be mixed with some areas hypoechoic and other areas hyperechoic. The hyperechoic areas are most likely due to local inflammation of the remaining pancreas. The hyperechoic areas are likely due to fibrosis and mineralization of the scarred pancreas. The pancreatic duct may be dilated. With acute pancreatitis, thrombi have been seen in the portal vein. These potentially may cause acute severe problems if the portal vein is completely obstructed.

**Pancreatic neoplasia**

Pancreatic neoplasia may be difficult to tell from pancreatitis in some instances. The history, lab data and thoracic radiographic films evaluating for the presence of metastatic lesions are useful. Two major types of pancreatic tumors are seen. The insulinomas are small and may not be seen. In people, 70% are solitary adenomas, 10% are multiple adenomas and 10% are malignant. The remaining 10% are diffuse hyperplasia or extra pancreatic. The size may vary from minute lesion to huge masses. 90% are less than 2 cm in diameter. If seen they are typically hypoechoic and singular but may be multiple. Regional lymph node and liver metastasis may be present and may be all that is detected. The history and lab data supporting hypoglycemia is especially important in the diagnosis. Gastrinomas, a G cell tumor, producing the Zollinger-Ellison syndrome are relatively uncommon. They may be small masses within the pancreas that result in abnormally high gastrin levels with subsequent gastric wall hyperplasia and ulcers. Pancreatic adenocarcinomas are often quite extensive by the time we see the patients. Adenocarcinoma: In people, approximately 70% of the pancreatic cancers arise in the
region of the head, 14-20% in the body and 5% in the tail. In 20% of cases the tumor is distributed diffusely throughout the gland. Metastases to the liver, mesentery, omental and peripancreatic nodes are characteristic. There may be marked disruption and enlargement of the pancreatic tissue. Complex hyperechoic tissue and mineralization may be present. Obstruction of the biliary tract and metastasis is often evident. Carcinomatosis may be identified as hypoechoic nodules on the peritoneal surface. Evidence of metastasis may be detected in other visceral organs especially the liver.
Imaging of the thorax is an important and useful technique. The heart is typically the organ imaged in the thorax. However, the lungs, the pleural space, mediastinum may be diseased and ultrasound helpful in diagnosing abnormalities. This talk will center on those non cardiac structures and how disease may appear on ultrasound and be diagnosed.

The cranial mediastinum should be evaluated for suspected masses, thrombi within major vessels or the possibility of perforation of the esophagus. The periphery of the lung, the pleural space, diaphragm, and pericardial sac and superficially of the heart should all be included in the examination of the cranial mediastinum.

Cranial mediastinum
The front leg is extended cranially. The heart is evaluated for cardiac or pericardial disease. Fluid and type of fluid (echogenic or anechoic) is noted either within the pericardial space or pleural cavity. The cranial mediastinum is sometimes challenging to image. The fat in this region and the small window between the lung lobes sometimes influences the complete examination. Normal lymph nodes are not typically seen unless enlarged. Masses in this area especially cysts or enlarged lymph nodes are imaged as hypoechoic or anechoic masses. Often they are well defined. Lymph node masses are not typically highly vascular. They may displace the major vessels within the mediastinum. Highly vascular masses are more likely tumors such as a thyroid carcinoma or heart based masses. These tumors have a propensity to invade local vessels and possibly obstruct them.

Lung
Typically, the lung is air filled and the ultrasound does not penetrate the surface and reverberation artifacts are generated. Disease in the lungs usually interferes with aeration of the lung. The usual reverberation artifact seen at the surface of the lung is affected. Nodules such as from metastasis may have sharp round margins. Pneumonia often has consolidation of the lung with poorly defined borders. Fluid or air may be seen in the bronchi in the consolidated lung—air bronchograms seen on the radiographs. Pulmonary edema (cardiac or non-cardiac) may increase the number of reverberation artifacts at the surface of the lung but not be as consolidated with the lung devoid of air as with other lung diseases. Lung lobe torsion and lung tumors appear as hypoechoic masses. If there is air remaining in a bronchus, then linear hyperechoic lines may be apparent. The consolidated lung looks like the liver (“drowned lung”). Tracing vessels or the bronchus or identifying the caudal vena cava and hepatic veins at the level of the diaphragm will be helpful in distinguishing a diaphragmatic hernia from a lung consolidation.

Pleural space
Pleural diseases such as pleural effusion from chylothorax, pyothorax, heart failure etc. may be documented and the character of the fluid helpful in determining if this is a transudate or exudate. A pneumothorax may be seen as air causing artifacts that do not change in position with breathing.

Ultrasound may help in the placement of a needle for aspiration or biopsy of fluid or a mass. A diaphragmatic hernia may be diagnosed with ultrasound. The appearance will vary depending on the contents and the location. Bowel loops may contain gas and produce reverberation artifacts. Usually they are easy to identify because of their shape, location crossing the diaphragm and their wall. Other abdominal contents are also usually easy to identify. The pericardial-peritoneal diaphragmatic hernias may have liver or GI present within the pericardial sac. It is important to try to assess viability of the different structures. Looking at blood flow and the echogenicity of the organs is beneficial. A liver that has vascular compromise may look like an infarcted spleen. It will be hypoechoic and may have thrombi within vessels. The gall bladder and the pancreas may also be within the thoracic cavity and be secondarily affected by the trauma.
Ultrasound Imaging of Lymph Nodes:  
The Big, the Bad, and the Ugly  
Kathy Spaulding, DVM, DACVR  
Texas A&M University  
College Station, TX

Lymph nodes within the abdomen are important indicators of extent or presence of disease. There is a multitude of different lymphocenters present within the abdomen. Specific lymph nodes to be evaluated in each examination include the medial iliac lymph nodes and the jejunal lymph nodes (mesenteric). The medial iliac lymph nodes located at the bifurcation of the aorta in the caudal abdomen. The mesenteric lymph nodes are located in the mid abdomen adjacent to the confluence of the jejunal veins into the portal vein. The normal glands are large enough to be seen in the dog and cat. Additional lymph nodes occasionally seen when they are infiltrated are varied. They are usually located adjacent to the organ they drain and close to vessels. They include: hepatic, gastric, pancreaticoduodenal, splenic jejunal, colic, aortic, renal hypogastric and sacral. The adjacent organs and vessels are used to name the lymph nodes. When a single lymphocenter is found to be abnormal, the region or organ that node drains should be closely examined for disease. Multiple lymphocenters involvement often indicates a more systemic involvement.

Normal lymph nodes may be seen and included each abdominal examination. Normal lymph nodes or reactive nodes may be uniformly slightly hypoechoic relative to surrounding fat and may have a hyperechoic strip in the center (the fat-strip sign). Older patients or patients on chemotherapy or steroids may be small and have an isoechoic or hyperechoic appearance. Normal glands have a fusiform shape and are relatively thin and uniform in echogenicity. The contour is smooth and often there is a thin hyperechoic capsule surrounding the gland. The medial iliac lymph nodes are often smaller cranially and slightly fuller caudally. The deep circumflex iliac vessels (artery and veins) cross over the isthmus at the cranial margin of the glands just ventral to L5-6. The jejunal lymph nodes are long and uniformly thin. There are a group of these lymph nodes that are gathered adjacent to these vessels. The jejunal (cranial mesenteric) arteries and veins are sandwiched centrally between two jejunal lymph nodes at the base of the mesentery. Vessels are very helpful in locating different lymphocenters. Lymph nodes in other locations may be more rounded or unique in appearance. Anatomic size references have been reported in dogs to have a maximum size of 5 mm- (Bezuedenhout 1993). However, glands 3-6 mm are within normal limits in the author’s experience depending on the size or the patient. When measured, it is usually the width that is recorded. The length is easier to incompletely have in the plane when measuring and more error can be encountered. There are variable sizes depending on the age, breed, size and species. Young dogs especially less than one year have mildly enlarged jejunal lymph nodes likely due to a reactive process associated with the intestinal exposure to multiple new antigens and inflammatory process. The glands should keep their normal shape. The shape is often helpful in determining an infiltrative process. A reactive process usually results in mild enlargement but retention of the normal shape. A ratio comparing the short and long axes should be less than 0.5 in normal nodes (Llabres-Diaz 2004; Nyman eta al 2004). The medial retropharyngeal lymph nodes (1cm width/.5cm height / 2.5 cm in length)

<table>
<thead>
<tr>
<th>Lymph Node Type</th>
<th>Normal Percentage</th>
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<tbody>
<tr>
<td>MILN-</td>
<td>100%</td>
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<tr>
<td>Jejunallymph nodes</td>
<td>90%</td>
</tr>
<tr>
<td>Hepatic lymph nodes</td>
<td>70%</td>
</tr>
<tr>
<td>Aortic lumbar, Splenic Pancreaticoduodenal -</td>
<td>60%</td>
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<tr>
<td>Ileocecal and Colic</td>
<td>50%</td>
</tr>
<tr>
<td>Renal</td>
<td>40%</td>
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<tr>
<td>Gastric,</td>
<td>30%</td>
</tr>
<tr>
<td>Sacral</td>
<td>20%</td>
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<tr>
<td>Caudal mesenteric</td>
<td>10%</td>
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</tbody>
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Abnormal lymph nodes change in size, shape, margin, echogenicity, and shape. They may have the entire gland affected or part of the gland involved. Depending on the disease and stage of disease, the glands become enlarged, lose the fusiform shape and become rounded.

Often lymph nodes with lymphosarcoma are large, have a rounded shape and are very hypoechoic.

Ratios that compare the long and short axes increase significantly with an infiltrative disease especially neoplasia. A Short/Long axis ratio > .5 has been used to predict neoplasia. Neoplasia often affects the internal appearance of the gland. This may include mineral (often from prostate gland or anal carcinomas). In people, the hyperechoic fat stripe is sometimes used to denote a benignancy and the loss of the stripe is used to indicate a malignancy. An infiltrated gland often becomes more hypoechoic and heterogeneous in appearance. The outside contour of the gland may become irregular. There may be extension of the tumor (especially lymphoma) to the root of the mesentery. It may become extensive and result in obstruction of the vessels at the root of the mesentery and subsequent devitalization of the intestine. The enlarged glands (other than systemic disease) are located adjacent to the affected organ. Exceptions include the sternal lymph nodes that drain the body wall and the peritoneal cavity. It is helpful to know what a specific lymphocenters drains and then to carefully examine that area. The medial iliac lymph nodes drain the pelvic limbs, the caudal abdominal cavity, and
the perineal region. It is important to note if both sides are affected or only one side. If only one side is affected it is useful to carefully scrutinize that side including the anal sac on that side. The glands may become cystic due to degeneration, abscess formation or associated with neoplasia. Granulomatous or inflammatory diseases such as Histoplasmosis, Pythiosis, Mycobacterium, FIP or others may mimic infiltration by neoplasia and may result in enlarged infiltrated glands. Following therapy especially for lymphosarcoma, the center of the lymph nodes often become hyperechoic as hemorrhage and necrosis occurs. Mineralization may be seen as bright hyperechoic areas. If they are large enough, then shadowing may occur. This feature is often seen with prostatic tumor or perineal carcinomas. Ultrasound is much more sensitive than radiology in detecting lymph node enlargement. Aspiration of lymph nodes is often useful in determining the extent of disease or the underlying cause for disease. It is most productive the larger the glands. Aspiration of only mildly enlarged glands especially the mesenteric lymph nodes is often unrewarding. The glands have a tendency to move away and few cells may be harvested. The vessels are close by and may be penetrated if the patient or gland moves. Even small cell lymphoma may not provide enough unique cells for the cytopathologist to make a diagnosis. When evaluating the lymph nodes, the appearance of surrounding structures is important in the overall interpretation. Other lymph nodes such as the medial retropharyngeal, the cranial mediastinal, axillary and other nodes are often examined when disease is suspected in the region. The evaluation of lymph nodes should be a part of every abdominal exam especially when attempting to diagnose an abnormality as cancer or to stage the cancer or for progression of disease as a response to therapy.

References
A Elke Schreurs, et al. Ultrasonographic Anatomy Of Abdominal Lymph Nodes In The Normal Cat. Veterinary Radiology & Ultrasound. 200849 (1);68-72