Ultrasound of the Gastrointestinal Tract

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KEYWORDS

• Ultrasound • Gastrointestinal tract • Enteritis
• Neoplasia • Obstruction

Familiarity with the normal and abnormal ultrasound appearance of the canine and feline gastrointestinal (GI) tract provides a marked advantage in the diagnosis of GI disease. Although gas may inhibit complete visualization, in many cases, ultrasound is able to confirm or rule out suspected disease. It should be noted that ultrasound of the GI tract does not preclude the need for abdominal radiographs. The two imaging modalities are complementary, and each adds individual information. Ultrasound evaluation of the GI tract provides information about bowel wall thickness and layers, assessment of motility, and visualization of important adjacent structures such as lymph nodes and peritoneum. In the hands of experienced sonographers, abdominal ultrasound has replaced the need for GI contrast studies in many cases, saving time, money, radiation exposure, and stress to the patient.

Techniques and approaches vary somewhat on patient conformation and position. Scanning the patient in dorsal recumbency allows relatively complete evaluation of the GI tract, although right and left lateral recumbency may be necessary to redistribute gas and fluid within individual portions of the stomach and bowel. Right lateral intercostal windows are often helpful in visualizing the pylorus and proximal duodenum in deep-chested dogs. Scanning the ventral abdomen of the standing dog or cat may allow improved visualization of the dependent pylorus and gastric body. In most patients, a high-frequency transducer (7.5 MHz or higher) is used for better visualization of stomach, small intestines, and colonic wall thickness and layers. A sector or curvilinear transducer is best for intercostal windows due to the smaller contact area of these probes.

The canine stomach can be accessed immediately caudal to the liver, at the level of the xiphoid. The feline gastric fundus and body are left-sided structures, with the pylorus located in a more midline location. In both species, the left-sided dorsal fundus should be followed ventrally and to the right, toward the pylorus, using both

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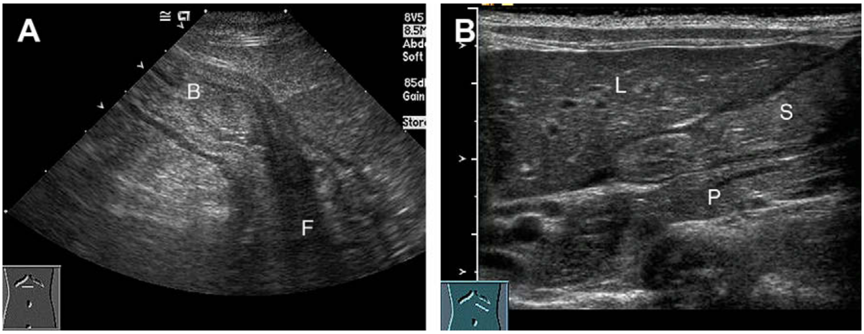

Fig. 1. (*A*) Ultrasound image of the long axis view of the normal canine stomach. The fundus (F) is located dorsally and to the left, with the body (B) located more ventrally and to the right. Normal gastric wall layers are noted. Some echogenic fluid is within the gastric lumen. The body image in the lower left corner of the image demonstrates transducer position. Ventral is at the top of the image, with right side of the body at the left side of the image. (*B*) Ultrasound image of the long axis view of the normal feline stomach (S). The liver (L) is located immediately cranial to the stomach, with the left limb and body of the pancreas (P) located just caudal to the stomach. The body image in the lower left corner of the image demonstrates transducer position. Ventral is at the top of the image, with the right side of the body at the left side of the image.

longitudinal and transverse imaging planes (**Fig. 1**). In many patients, intraluminal gas allows visualization of only the near wall. Reverberation artifact and shadowing lie deep to the echogenic gas interface, masking the lumen and far walls. In non–deep-chested dogs, or dogs with hepatomegaly, the pylorus can often be followed into the proximal duodenum from the ventral abdominal window. In cats, all parts of the stomach, including the pyloric-duodenal junction, are commonly seen. The canine descending duodenum is consistently located along the right lateral abdominal wall, just ventral and either medial or lateral to the right kidney (**Fig. 2**). In the dog, the descending duodenum is larger in diameter and follows a more linear cranial to caudal path than the adjacent jejunal segments. The feline duodenum is located closer to the midline and is the same diameter as the jejunum. It may appear segmented, representing the "string of pearls" sign often noted on barium contrast studies. In both species,

Fig. 2. Ultrasound image of the longitudinal view of the normal canine descending duodenum. The duodenum is located immediately ventral to the right kidney (RK) as it extends from cranial to caudal along the right lateral abdomen. Ventral is at the top of the image, with cranial on the left side of the image.

Fig. 3. Transverse image of the proximal duodenum at the level of the duodenal papilla. The bile duct (*arrow*) is visible entering the papilla. Ventral is at the top of the image, with the right on the left side of the image.

the duodenal papilla is visualized as a small focal nodule entering the proximal duodenum (**Fig. 3**).

Jejunal bowel loops are found throughout the abdomen. Although much of the jejunum can be seen while evaluating the major abdominal organs during the complete examination, a careful systematic scan over the mid-abdomen should be done for a more complete bowel examination.

In cats, the ileo-ceco-colic junction is consistently seen, just medial to the right kidney and adjacent to the colic lymph nodes. A smaller cecum, with less intraluminal gas, allows more consistent evaluation than in the dog, where cecal and colonic gas usually masks this area (**Fig. 4**).

The colon is usually the most difficult portion of the GI tract to evaluate due to intraluminal gas and fecal material. The transverse colon lies immediately caudal to the stomach. The descending colon can be followed caudally, where it lies just dorsal to the bladder (**Fig. 5**).

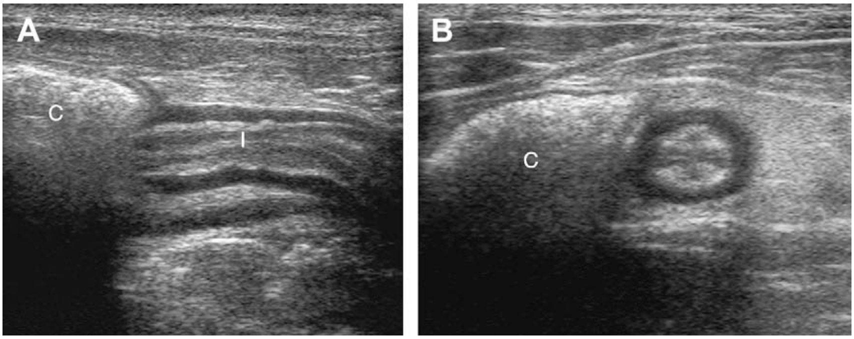

Fig. 4. (*A*) Longitudinal image of the normal feline ileo-colic junction. The terminal ileum (I) is seen entering the gas-filled colon (C). Ventral is at the top of the image, and cranial is to the left. (*B*) Transverse image of the normal feline terminal ileum just before it enters the gas-filled colon (C). Note the "wagon-wheel" appearance of the layers in the ileum. Ventral is at the top of the image, with the right on the left of the image.

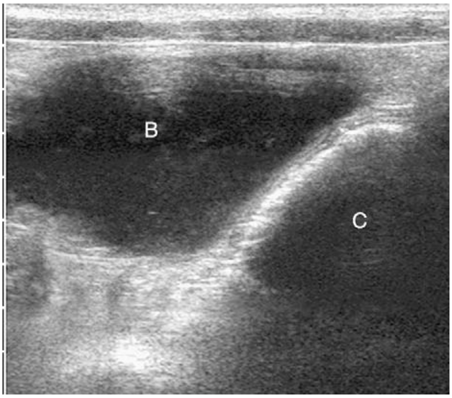

Fig. 5. Longitudinal image of the bladder (B) and descending colon (C). The gas-filled colon is normally seen just dorsal to the bladder in the caudal abdomen. Ventral is at the top of the image, with the cranial at the left.

NORMAL APPEARANCE

Five distinct layers are visible in the wall of the stomach and intestine (**Fig. 6**).[1–6] A bright hyperechoic mucosal-luminal interface is seen centrally. Peripheral to this interface is the hypoechoic mucosal layer, followed by a thin hyperechoic submucosa. Continuing peripherally is a thin hypoechoic muscularis layer, followed by the outermost hyperechoic serosa. The mucosal layer is normally thicker than the other layers in the small bowel. In the stomach, however, the muscularis layer is equal in thickness to the mucosal layer. Wall layers are best examined with a high-frequency transducer. Normal wall thicknesses for the intestines and stomach have been published (see **Table 1**).[1–6] In the dog, duodenal and jejunal thickness is dependent on body weight. All wall thickness measurements are taken from the inner mucosal interface to the outer aspect of the serosa (see **Fig. 6**). Wall thickness can be difficult to evaluate in the collapsed stomach, where the lumen is sometimes difficult to separate from the

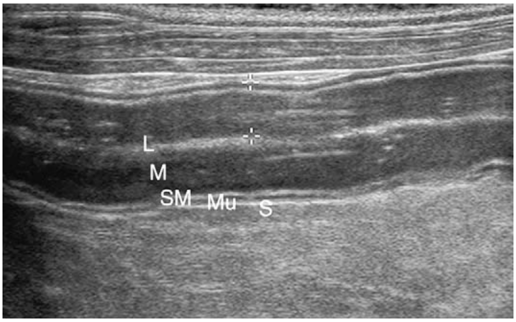

Fig. 6. Longitudinal image of the descending duodenum illustrating the individual wall layers. The hyperechoic mucosal-luminal interface (L) is centrally located and is followed by the prominent hypoechoic mucosal layer (M). The submucosa (SM) is a thin hyperechoic layer adjacent to the mucosa and is followed peripherally by the thin hypoechoic muscularis layer (Mu). Most peripheral is the thin hyperechoic serosal layer (S). Note the relative thickness of the layers; the mucosal layer is normally the thickest.

Table 1
Range of normal gastric and intestinal segment wall thicknesses

GI Segment	Canine (mm)	Feline (mm)
Stomach	3–5	1.1–3.6
Duodenum	2–6	1.3–3.8
Jejunum	2–4.7	1.5–3.6
Ileum		2.5–3.2
Colon		1.1–2.5

Data from Refs.[1–6]

wall. When gastric wall measurements are taken, it is important to measure between rugal folds to avoid artifactual increase in thickness. The normal but contracted stomach can also appear artifactually thickened.[7]

The stomach is occasionally empty but usually contains gas, fluid, or ingesta. Food aggregates appear as hypoechoic structures that move with peristalsis. Unlike true mass lesions, food does not persist when serial examinations are performed over time. When the stomach is empty, prominent rugal folds are visible. These are especially prominent in the cat, where they resemble spokes on a wheel (**Fig. 7**). The small intestines, usually empty, may also contain fluid or gas and, occasionally, ingesta. Fecal material and gas typically fill the colon, making wall measurements difficult. The terminal ileum in the cat is usually visible entering into the colon. The ileum has a more prominent muscularis and submucosa layer than other parts of the feline intestine and resembles a "wagon wheel" when seen in cross section (see **Fig. 4**).[6]

GI motility can be assessed by counting peristaltic waves. Typically, the stomach and small intestines undergo about three to five contractions per minute.[1]

ABNORMAL APPEARANCE

The stomach and bowel should be evaluated for wall thickness, appearance of wall layers, peristaltic activity, and luminal contents and diameter. Adjacent lymph nodes should be evaluated for enlargement, and the presence of free gas or fluid should be noted.

Fig. 7. Transverse image of the normal feline fundus. Note the prominent rugal folds resembling "spokes on a wheel." Ventral is at the top of the image, with the right side on the left of the image.

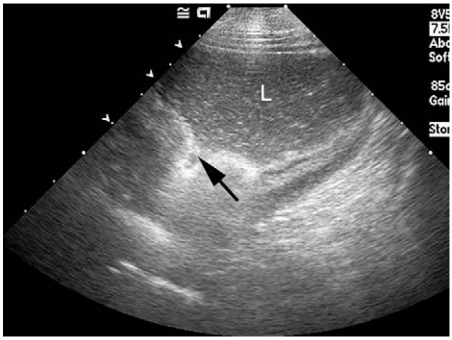

Fig. 8. Longitudinal image of the pyloric outflow area of a dog presenting with chronic vomiting. The pyloric outflow is markedly narrowed (*arrow*) by thickened pyloric walls. The lumen (L) caudal to the pylorus is distended with fluid. Lymphosarcoma was diagnosed with endoscopic biopsies.

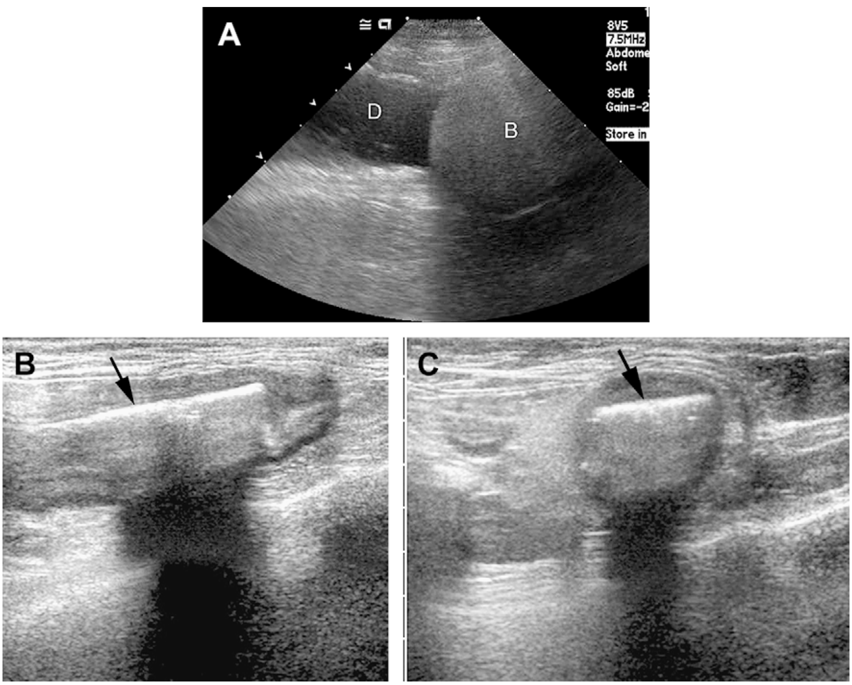

Fig. 9. (*A*) Longitudinal image of the descending duodenum. The duodenal lumen (D) is distended with fluid. An echogenic structure with round, well-defined margins (B) is obstructing the duodenum. A ball foreign body was removed surgically. Ventral is at the top of the image, with the cranial to the left. (*B*) Longitudinal and (*C*) cross-sectional images of the jejunum of a cat presented for vomiting. A well-defined linear echogenic structure (*arrows*) with acoustic shadowing is present within the jejunal lumen. This structure did not change in appearance or move with peristaltic activity. Plastic foreign material was removed surgically.

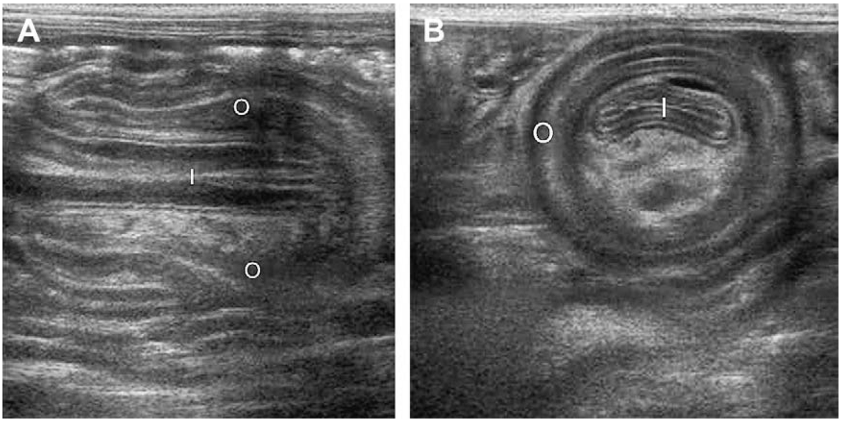

Fig.10. Longitudinal (*A*) and cross-sectional (*B*) images of a jejunal intussusception in a puppy presented for vomiting. The intussusceptiens (O) are located outside the inner intussusceptum (I). Hyperechoic mesenteric fat is present adjacent to the intussusceptum.

OBSTRUCTION

Ultrasound examination is very helpful in determining if a pyloric or intestinal obstruction is present, and, when performed by an experienced sonographer, may replace a contrast GI series for confirmation of obstruction.[3,4,8,9] The actual cause of the obstruction may be better visualized on ultrasound examination than abdominal radiographs. Pyloric outflow obstruction, especially if chronic, usually results in fluid distension of the gastric lumen. The fluid enhances visualization of the pylorus and any potential foreign bodies or wall thickening (**Fig. 8**). The same is true of the small intestine, and any luminal distension should be followed to determine if an obstructive lesion is present. The appearance of a foreign body varies depending on the composition.[3,4,8–10] Some foreign objects, such as some types of balls, have through transmission, permitting visualization of the actual shape and size. However, many foreign bodies result only in a bright echogenic interface with acoustic shadowing. Only the near surface is visible and may have an irregular or more linear or curvilinear shape

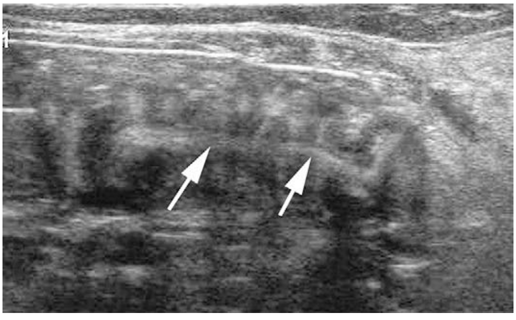

Fig. 11. Longitudinal image of a segment of jejunum in a cat presented for vomiting. The bowel segment is severely plicated, with a persistent linear echogenic structure extending through the lumen (*arrows*). A linear foreign body was removed surgically.

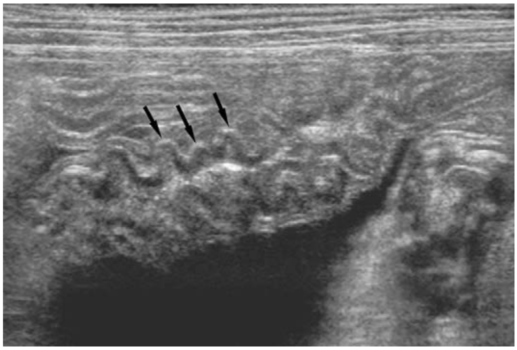

Fig. 12. Longitudinal image of a segment of jejunum in a dog with uroabdomen. Anechoic free fluid surrounds a segment of corrugated jejunum. Note the "rippled" appearance of the bowel, most apparent in the hyperechoic submucosal layer (*arrows*).

that usually takes the shape of the foreign material (**Fig. 9**). The bowel proximal (orad) to the obstruction is usually dilated with either gas or fluid.

INTUSSUSCEPTIONS

Ultrasound is an excellent imaging modality for the diagnosis of intussusceptions, as they are easily visualized and characteristic in appearance. When seen in cross section, the multiple bowel wall layers involved result in a bull's-eye or target-like appearance (repeated concentric rings).[3,4,9–13] These same multiple layers aligned in a parallel fashion are seen in longitudinal image planes (**Fig. 10**). Mesenteric fat is often carried in along with the intussusceptum (inner bowel loop), creating a bright, hyperechoic signal around the intussuscepted bowel segment. There is usually dilation of the section of the bowel orad to the intussusception.

LINEAR FOREIGN BODIES

Linear foreign bodies may also be identified on ultrasound examination.[3,4,9] The affected segment of bowel appears plicated or bunched, just as it does on abdominal radiographs. A persistent echogenic linear structure is often seen extending through the plicated bowel, representing the linear foreign material (**Fig. 11**). This linear

Fig. 13. Transverse image of the proximal duodenum in a dog with severe pancreatitis. The duodenal layers are maintained but have lost some of their definition secondary to inflammation. Compare this image of the duodenum to the normal transverse image in **Fig. 3**.

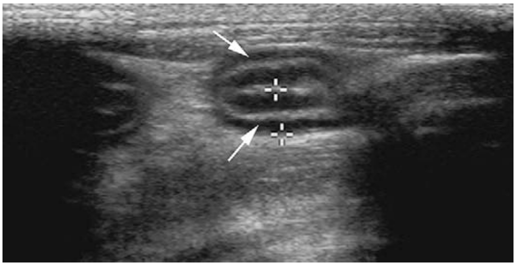

Fig. 14. Transverse image of a segment of jejunum in a cat with inflammatory bowel disease. The muscularis layer (*arrows*) is prominent and equal in thickness to the mucosal layer. The overall bowel wall thickness (*between calipers*) was increased at 3.5 mm.

echogenic structure does not change appearance or move with peristalsis. The stomach should always be checked for an anchoring portion of the linear foreign body, if not found under the tongue. Intussusceptions may occur secondary to linear foreign bodies and may be found in addition to plicated bowel. Corrugation of bowel, with a characteristic "rippling" of the submucosal layer, is seen with inflammation and should not be confused with intestinal plication (**Fig. 12**).

INFILTRATIVE DISEASE

The ultrasound appearances of canine and feline GI inflammation and neoplasia can overlap, with changes typically more dramatic and severe with neoplasia and milder and more subtle with inflammation.[3,4,14] In many cases of gastritis and enteritis, no ultrasound changes are visible. However, findings consistent with GI inflammation include diffuse or multifocal mild wall thickening, loss of definition of wall layers, and mesenteric lymphadenopathy (**Fig. 13**).[3,4,14–16] In one study, dogs with enteritis had an average wall thickness of 0.6 cm. In separate studies, however, small intestinal wall thickening was not sensitive or specific for enteritis, and normal bowel wall thickness should not rule out inflammatory disease.[15,17] Bowel wall layering can appear normal in the face of inflammation but may also have a mild loss of definition. Increased prominence of the muscularis layer (equal or greater in thickness to the

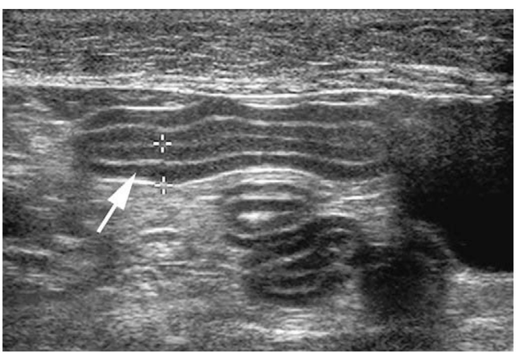

Fig. 15. Longitudinal image of a segment of jejunum in a cat with GI lymphosarcoma. The muscularis layer (*arrow*) is prominent and thickened, and overall bowel wall thickening is present (measured between calipers). Note the similarity in appearance to inflammatory bowel disease in **Fig. 14**.

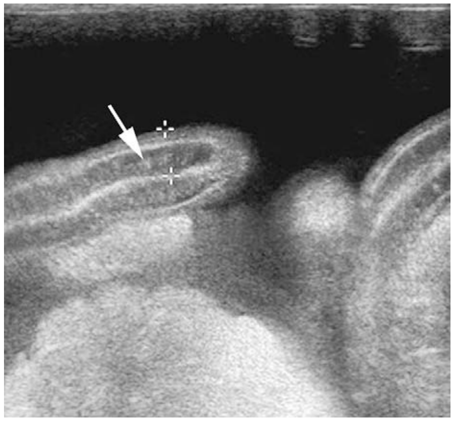

Fig. 16. Longitudinal image of a segment of jejunum in a dog with lymphangiectasia. Anechoic free fluid is present. The mucosal layer contains multiple hyperechoic striations (*arrow*) consistent with dilated lacteals.

mucosal layer) has been reported with inflammatory bowel disease, primarily in the cat (**Fig. 14**).[16,18,19] Chronic partial obstruction can result in hypertrophy of the muscularis layer, giving the same appearance. Intestinal lymphosarcoma can also result in thickening of the muscularis layer and should always be considered as a differential diagnosis for a thickened muscularis layer (**Fig. 15**). Other ultrasound findings associated with enteritis in the dog and cat include mesenteric lymphadenopathy, although lymph node enlargement is usually mild compared with lymph nodes with neoplastic involvement (1.0 cm or less in thickness; normal is $\leq$5 mm).[14] Hyperechoic speckles and striations within the mucosal layer likely represent dilated lacteals and can be seen with inflammatory bowel disease and lymphangiectasia in the dog (**Fig. 16**).[3,20] Peritoneal effusion frequently accompanies lymphangiectasia. Bowel corrugation or "rippling" (seen best in the submucosal layer) can also occur with enteritis but is a somewhat nonspecific sign (see **Fig. 12**).[21] Corrugation has also been reported with peritonitis, pancreatitis, uroabdomen, bowel ischemia, and lymphosarcoma.

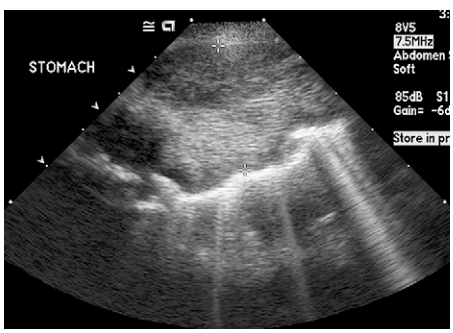

Fig. 17. Longitudinal image of the stomach in a dog with gastric carcinoma. The near wall of the stomach (*between calipers*) is markedly thickened. Alternating hyperechoic and hypoechoic layers are present consistent with pseudolayering. These pseudolayers do not correspond to the normal histopathologic wall layers.

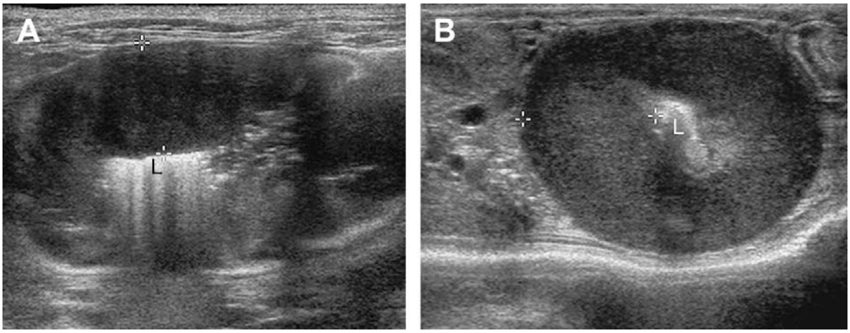

Fig. 18. Transverse images of the stomach (*A*) and duodenum (*B*) in a dog with GI lymphosarcoma. In both stomach and duodenum, the walls are hypoechoic and severely thickened (*between calipers*), with complete loss of layers. The lumen (L) is present as a hyperechoic interface in the center of the stomach and duodenum.

NEOPLASIA

Gastric and intestinal neoplasia most commonly results in more dramatic wall thickening with complete loss of wall layers.[3,4,10,14,22] In one report, the average intestinal wall thickness in dogs with intestinal neoplasia was 1.5 cm, much higher than that reported for enteritis.[14] Complete loss of visualization of wall layering is common with either gastric or intestinal neoplasia and is considered the most specific ultrasound indication of neoplastic disease.[14] Individual wall layers are replaced by a more uniform hypoechoic thickening in many cases, although more complex masses may also occur. Neoplastic masses in the intestines are usually focal, or multifocal, and can be annular or eccentric, extending out of the lumen. Enteritis typically has more diffuse involvement. It should be remembered, however, that some neoplastic lesions are subtle, and difficult to differentiate from inflammation. Mesenteric lymph nodes are usually more dramatically enlarged with neoplastic involvement, with an average thickness of 1.9 cm in one study.[14] Although cytology or histopathology is necessary for a definite diagnosis, some GI tumors have ultrasound characteristics that may allow a preliminary diagnosis. Gastric adenocarcinoma has been reported to cause

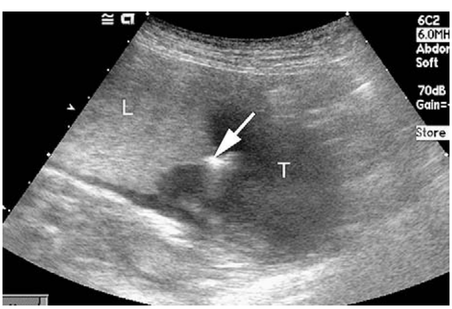

Fig. 19. Longitudinal image of a segment of jejunum in a dog presented for chronic vomiting and weight loss. The lumen (*arrow*) is almost completely obliterated by an intestinal mass (T) growing circumferentially around the jejunum. The portion of bowel orad to the mass (L) is dilated with echogenic fluid secondary to obstruction. The mass was removed surgically and diagnosed as adenocarcinoma.

"pseudolayering," with alternating hypoechoic and hyperechoic layers in the thickened wall that do not correspond to actual histologic wall anatomy (**Fig. 17**).[23] Lymphosarcoma tends to be multifocal or involve long segments of bowel, whereas intestinal adenocarcinoma is more often focal, often causing partial or complete obstruction (**Figs. 18** and **19**).[14,24–27] Leiomyosarcoma originates intramurally and may bulge out of the serosa as an extraluminal mass. The masses often contain hypo/anechoic areas, likely representing central necrosis.[28]

GI inflammatory diseases are best diagnosed with biopsies taken during endoscopy or laparotomy. However, neoplastic masses may be successfully diagnosed using ultrasound-guided, fine-needle aspiration or even tru-cut biopsy if large enough. The bowel or gastric lumen should be avoided during biopsy procedures.

SUMMARY

Ultrasound of the stomach, small bowel, and colon is extremely helpful in the diagnosis of obstructive lesions, inflammation, and neoplastic disease. Although gas can preclude complete visualization of portions of the GI tract, disease processes can often be well visualized. Evaluation of the stomach and bowel should be included in the complete ultrasound examination.

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