Further information regarding interventional procedures and case studies may be found at www.SonoPath.com

Our recent unpublished research has shown that underlying Gi disease is frequently present along with Gi foreign bodies in 25 dogs and cats. Histopathology diagnosis in the cats was inflammatory bowel disease (4), lymphoma (5), and carcinoma (2); whereas in dogs the histopathology diagnosis was inflammatory bowel disease (6), lymphoma (3), necrotic enteritis (3), and carcinoma (2).

Prior to this research we established solid repeatable criteria for Gi obstruction from the sonographic approach:


Retrospective analysis was performed on sonograms in 39 cases of dogs and cats that were found to have gastrointestinal obstruction upon surgical laparotomy. The following sonographic parameters were analyzed:

1) Proximal luminal gastrointestinal dilation  
2) Proximal gastrointestinal hyperperistalsis  
3) Presence of a foreign object at the end of the dilation  
4) Type of acoustic shadow at obstruction site  
5) Empty post obstruction intestinal lumen

Small intestinal luminal dilation and shadowing was differentiated from colonic dilation and colonic “dirty shadow” by following the colon from the pelvic inlet cranially into the ileocecal valve in retrograde fashion. Obstructive pathology was found to largely be owing to foreign objects with variable degrees of acoustic shadowing with 2 exceptions that lacked shadowing by the foreign object. The degree of luminal dilatation varied greatly and was somewhat dependent on the physical character of the foreign object, primarily that of its absorptive capabilities such as that of a corn cob, fabric, or wood products. Some cases presented echogenic, ill-defined serosal inflammation and/or overt peritonitis in the region of obstruction. Some cases also presented with obstruction with concurrent ileus. Periserosal fat inflammation and loss of serosal detail was found to be consistent with inflammation noted at surgery and was used as an urgency factor during the sonogram to recommend imminent surgical intervention.

1) Proximal luminal gastrointestinal dilation was present in 39/39 cases.  
2) Proximal gastrointestinal hyperperistalsis was present in 34/39 cases. The remaining 5 cases were determined to possess mechanical ileus owing to “exhausted bowel.”  
3) An obstructive foreign object was discovered at surgery in 39/39 cases.  
4) Acoustic shadowing was strongly present in 30 cases. Mild acoustic shadowing or “dirty shadow” similar to colonic content was present in 7 cases. Two cases did not present with an acoustic shadow on ultrasound.  
5) Empty post obstruction intestinal lumen was definitively evident in 27/39 cases. Post obstruction fluid was present in 2 cases, and undecided in 10 cases. From this study group of 39 cases, a consistent set of sonographic criteria for gastrointestinal obstruction can be utilized and combined with clinical signs and other testing in order to select medical versus surgical therapy for the patient presenting with gastrointestinal signs.
Another useful technique we developed based on need in the field for a more precise GI surgical sampling procedure is:

Intraoperative ultrasound: We developed this technique to be used on any abdominal organ but is especially effective in case of infiltrative, focal and multifocal GI lesions. The problem is that the surgeon cannot often see what the clinical sonographer is observing from a transabdominal sonographic perspective. If the organ serosa is not visibly affected, the surgeon will simply perform a “shopping spree” of intestinal biopsies as opposed to a precise sampling procedure of the most representative lesion that we observe sonographically. Hence we may identify and resect the most representative mural lesions with this method.

Procedure: Acoustic gel is placed into a double surgical glove to keep the outside exposed glove sterile. Cold sterilize the ultrasound probe with alcohol before putting it in the glove. Pull the glove tight on top the probe to ensure adequate probe/gel/glove coupling occurs to avoid any air entrapment. Have the surgeon exteriorize the bowel or expose the target organ to be sampled. A technician pours saline on the bowel (or other organ) as a coupling agent. Scan the organ to define the most representative region of the mural pathology that was observed transabdominally. Then define the best healthy tissue where the infiltrative pattern or pathology subsides and resect the lesion at this identified point of healthy tissue proximal and distal to the affected region. This procedure should take the sonographer 10 minutes or so and the surgeon may do the rest. (Images)

More on this technique may be seen in our abstract from ECVIM 2009 (Intraoperative Ultrasound for Precise Biopsy and Resection of Transabdominally Detected Intestinal Lesions in 3 cats. Lindquist, Casey, Frank)

www.sonopath.com/resources.html

For general techniques regarding GI Sonography we offer an excerpt from our Clinical approach textbook that is now in editing:

Conceptual Considerations for Sonographic Imaging of the Gastrointestinal Tract

Ultrasonography is a valuable imaging method to evaluate the gastrointestinal tract. Preoperative ultrasonography has been shown to provide good agreement between sonographic and surgical findings. That being said, operator experience plays an important role in the sensitivity of detecting gastrointestinal lesions. Intraluminal gas and ingesta frequently interfere with complete GI tract imaging, but with experience this will become less of an obstacle.

An effort must be made not only to image the entire GI tract, but also to acknowledge those regions that may not have been adequately imaged, and plan alternative ways (i.e. contrast radiography, endoscopy, laparoscopy, surgery) to define these areas. Lack of appropriate detail in imaging the GI tract can also be equipment dependent, and higher resolution images are frequently needed. For example, gastrointestinal ulceration and perforation have been shown to be less consistently discovered sonographically.

Imaging of the GI tract can also be optimized by withholding food 12-24 hours, utilizing sedation, attempting water ingestion immediately prior to the scan, manipulating the colon manually with the scanning hand, and utilizing lateral and intercostal angles especially when imaging the pylorus.

Regardless of the sonographic presentation and abilities of the sonographer to thoroughly image the entire pathological presentation of the patient, it is essential that the presentation be interpreted while keeping all available clinical data in mind. The supporting clinical data adds worth to the interpretation of the sonogram, which is only one of the tests to be performed in a thorough gastrointestinal and systemic work-up.

Ultrasound and Structural Aspects of the Normal GI Tract

- Anatomy
  - Stomach regions: Cardia, fundus, body, antrum, pylorus
  - Small intestine: Duodenum, jejunum, ileum
  - Large intestine: Ascending, transverse and descending colon

- GI layers seen with ultrasound
Lumen
- Hyperechoic line corresponds to mucosa/luminal interface in the empty bowel
- Thicker anechoic or echogenic region in center corresponds to fluid and/or ingesta within the lumen

Wall
- Mucosa: Hypoechoic
- Submucosa: Hyperechoic
- Muscularis: Hypoechoic
- Serosa: Hyperechoic

GI wall thickness (see Tables 3 and 4)
Stomach
- Dogs: 3-5 mm
- Cats: 1.7-2.4 mm
- Duodenum (varies with body weight)
  - Dogs: 5.1-6.0 mm
  - Cats: 2.0-2.7 mm
  - Jejunum, ileum in dogs (varies with body weight): 4.1-4.7 mm
  - Jejunum in cats: 2.1-2.5 mm
  - Ileum in cats: 2.5-3.2 mm
- Colon:
  - Dogs: 2-3 mm
  - Cats: 1.4-1.7 mm

In general, the layers are similar in appearance in the stomach, small intestine while the colon typically presents a thin wall unless pathology or hypertrophy is present. The layers are normally straight in a sagittal plane, curved in a transverse plane, and are well-defined with a curvilinear contour. An echogenic stripe can be seen through the mucosal layer when the bowel is flattened, empty and contracted when seen in transverse view. Rugal folds can be readily seen in the stomach if it is not distended.

The stomach can be imaged from left or right intercostal views to avoid gas and ingesta artifact as well as from the subcostal and subxyphoid planes. Full assessment of this dynamic organ is essential to examine content and mural structure. Thorough examination of the pyloric outflow can be extremely useful in the assessment of subtle chronic upper GI clinical signs and should be a routine part of the “C-loop" clip described for the portal hilus during the hepatic lecture. Pyloric stenosis, infiltrative neoplasia, granulomatous disease, pyloric spasm, foreign bodies and hypertrophy gastropathy can readily be imaged in this region as demonstrated in the legends section of this chapter. Patients and intercostal weight dependent manual manipulation are all important to routinely master this view with all of its challenges such as artifact, body conformation difficulties, and patient resistance.

The duodenum can be identified by its superficial, sagittal orientation in the right cranial abdomen and continuity with the pylorus. This is often best imaged from a right lateral intercostal approach or by a retro costal right lateral approach with forefinger displacement of the ascending colon and scanning with the supinating “c-loop" maneuver. It is important to make the effort to view the entire proximal duodenum. Many patients form a dorsal loop beginning at the pylorus extending cranially prior to continuing caudally in a descending fashion, especially in deep chested dogs or those with micro hepatica. Sonographers can miss occult disease in this region if adequate views are not obtained. Patients with prominent right liver lobes may not possess this loop given the impingement from the right liver displaces the proximal descending duodenum into a more caudal position.

The duodenal papilla can be identified with a high resolution probe located a few centimeters distal from the pylorus. It is important to follow the common bile duct into the duodenal papilla if duct dilation or hyperbilirubinemia is present. Biliary plugs, calculi, strictures, neoplasia and granulomatous or inflammatory disease can reside here. Passive, manual manipulation of colonic artifact and patient body wall resistance is often essential here to gradually obtain a clear view of the entire biliary and pancreatic duct/papillae regions.

In the dog, the duodenum, jejunum and ileum have a similar appearance, although the duodenal wall is thicker than other regions of small bowel.

In the cat, the ileum has a distinctive ‘wagon wheel’ appearance at the ileocecal junction.

Increased wall thickness, loss of wall detail, abnormal luminal content, and altered motility are all factors
to assess regarding intestinal pathology. Scanning the entire small intestinal tract and distinguishing it from colon is essential in order to distinguish focal lesions from multifocal and diffuse patterns. The small intestinal sonographic pattern is crucial to defining the lesion as “surgical” or “medical” in nature in which sampling and therapy could be the less invasive and more logical approach to the presentation. Obstructive and partially obstructive descriptions also are important when describing small intestinal patterns in that surgical debulking may allow for adequate transit of ingesta and better nutrient management while medical therapy further refines the outcome.

The colonic wall is typically thinner than the small intestinal wall, and often has a crescent shaped hyperechoic interface with incomplete ‘dirty’ acoustic shadow within the lumen, corresponding to feces and gas (also known as a “gas curtain”). The descending colon can also be identified by its sagittal orientation along the left lateral abdomen and continues into the pelvic inlet distinguishing it from other portions of the intestinal tract. The colon can be followed in an ascending manner on the right, transverse to the left and descending into the pelvic inlet adjacent to the urinary bladder. This is important when assessing bowel stasis and evaluation for possible obstruction criteria given that colonic stasis can mimic a small intestinal obstructive pattern.

**Imaging Methods for the GI Tract**

Image the fundus and body of the stomach starting from the subxyphoid location and then slide to the left. A high left intercostal approach may be best if gastric or colonic gas is present. Image the duodenum starting lateral to the right kidney. Follow the duodenum cranially (intercostal if necessary), then somewhat dorsally to the pylorus. Follow the pylorus to the antrum, then to the body and fundus of the stomach. Mid dorsal right intercostal (or retro costal) approaches may be necessary to image the pylorus and upper duodenum. This is especially true in cases of deep-chested dogs or patients with micro hepatica. Medial manual displacement of the ascending colon with the index and middle fingers will allow the probe angle to circumvent the intraluminal gas/stool acoustic shadow. This is best accomplished when the patient’s body is at a 45 degree angle, between dorsal and right lateral recumbency. The sonographer can also elevate the cranial end of the animal to help displace the peritoneal contents caudally. The pylorus lies dorsal to the duodenum and antrum, thus scanning angle must be altered.

The small intestine can be imaged by slowly transitioning from sagittal to transverse, using a grid pattern to cover the entire mid-abdomen. Patient, thorough scanning and at least 2-4 passes across the mid abdomen should help to look around and between acoustic shadowing from luminal gas. Image the feline ileum by fanning medial to the right or left kidney in the sagittal plane. When the transverse colon is imaged, rotate the probe to search for the ileum in the sagittal and transverse plane. Also the sonographer can look for the ileum’s abrupt termination into ascending colon’s gas curtain. The “wagon wheel” sign can be found here. Survey scanning between the ileum and colonic region, the ileocecal colonic junction and associated lymphadenopathy can be seen. Gravity dependent imaging can help circumvent intraluminal gas. Mesenteric root lymph nodes are usually located medial to the kidneys and dorsal to colonic gas/stool artifact and are often “reactive” or “infiltrated” in cases of intestinal insult.

**Table 1. Examples of primary GI disease**

- Food intolerance/allergy
- Dietary indiscretion
- Pyloric stenosis
- Neoplasia
- Infectious disease
- IBD
- Ulceration
- Intussusception
- Foreign bodies
- Torsion
- Infarction
- Motility disorders
- Obstruction
- Dilatation-volvulus
- Hypertrophic pyloric gastropathy
Table 2. Examples of secondary GI disease

- Renal disease
- Hepatic disease
- Diabetic ketoacidosis
- Hyperthyroidism in cats
- Hypoadrenocorticism
- Pancreatitis
- Peritonitis
- Drugs/toxins
- Non-GI abdominal neoplasia
- Neurological disease

When to Sample the Lesion

- Mass
- Wall thickening
- Protein losing enteropathy
- Vomiting and/or diarrhea
- Weight loss with good appetite
- Persistent GI blood loss

Sampling Methods

There are two methods in which to biopsy the bowel with the aid of U/S: FNA (fine needle aspiration) and core biopsy.

- Lesion < 2 cm: FNA.
- Lesion > 2 cm: FNA, Tru-cut biopsy (18-gauge), or surgical biopsy.
- Avoid GI lumen
- Generally regarded as a safe procedure with a low risk of complications.

Endoscopic biopsies are limited to the mucosal tissue. The lesion must be luminally accessible via an endoscope in order to obtain an adequate sample for pathological review. One study demonstrated that endoscopic biopsies can be adequate for diagnosing gastric lymphoma but fail to adequately differentiate IBD from lymphoma in the small intestine. From the author’s experience, aspirates are usually informative for cellular pathology such as lymphoma, carcinoma and mast cell neoplasia. Structural disease such as leiomyosarcoma, fibrosing or granulomatous IBD, and fibrosarcoma tend to be less informative or non-diagnostic with less optimal recovery of informative cells upon sampling.

Therefore, as with other organ systems, this theme that FNA often is adequate for cellular pathology and biopsy is much more accurate for structural pathology likely holds true as it does for sampling of other organ systems such as the liver. However, no studies were found prior to publication that examines the difference in accuracy of US-guided FNA versus US-guided Tru-cut biopsy with regards to specific types of gastrointestinal pathology. As a rule Tru-cut biopsy, if able to be safely obtained, is always best to more accurately represent the pathology at hand while surgical biopsies represent the optimal method of sampling. But FNA can prove adequate with many types of gastrointestinal pathology.

An ultrasound exam prior to an endoscopic exam will allow for differentiating mural pathology from mucosal pathology. In this manner the practitioner may decide whether full thickness biopsies, US-guided biopsies, or endoscopic sampling would be the best approach while also weighing the benefits of a less or more invasive method of sampling. The fact that surgically obtained biopsies are superior to endoscopically obtained samples has been established. Sonographic assessment prior to selecting endoscopic sampling, US-guided FNA or biopsy, or surgical biopsy may allow for a more accurate and targeted sampling procedure. This “pick your battles” approach is why the author advocates also utilizing intraoperative sonographic guidance in order to further optimize lesion sampling that may not be overtly visible at the serosal surface or physically palpable during surgery surgical approach.
Luminal pathology can be better identified by means of intraoperative ultrasound. In addition, the mural extension of disease may also be defined by this method in terms of resection of the pathology originally seen during the preoperative sonogram. For example, the surgeon may not be readily able to localize a regionally thickened muscularis or regions of loss of mural detail that would best be resected and sampled at the time of surgery. The sonographer can individualize these regions intra-operatively with the probe (with gel filled surgical glove) and allow for definitive resection of pathology mural or luminal pathology that may taper or be multifocal in nature.

In addition, the availability of PCR analysis for lymphosarcoma (Colorado State University) on cytologic samples could improve the accuracy of FNA regarding the differentiation of lymphoma from “lymphoid” samples or lymphocytic plasmacytic inflammatory disease). However, this test has only recently been introduced and merits further study regarding accuracy in the various organ systems. Regardless, PCR analysis for lymphoma does provide a diagnostic option to consider before the more invasive full-thickness surgical biopsies are to be obtained.

**Differential Diagnoses for Ultrasound Findings in the GI Tract**

Infiltrative diseases can present in a variety of ways, and there is a large amount of overlap in the differential diagnosis of ultrasound findings. In general, loss of GI layering is more commonly associated with neoplasia, and normal layering is more commonly associated with inflammatory disease. Most infiltrative diseases have increased wall thicknesses. Wall thicknesses in cats with alimentary lymphoma were found to range from 8-22 mm in the stomach and 5-20 mm in the intestine. It has been demonstrated that dogs with wall thicknesses greater than 1cm have a greater probability to have intestinal neoplasia as opposed to inflammatory disease. However, examples of inflammatory disease with wall thickness greater than 1 cm and infiltrative neoplasia with wall thickness less than 1 cm can be found in practice. Regardless, this type of presentation is often considered the exception rather than the rule. Moreover, malignant transformation of IBD to lymphoma can occur and the gastrointestinal presentation may provide aspects of both “inflammatory” and “neoplastic” simultaneously in the same patient (see case presented during lecture).

Current research investigating changes seen in individual bowel layers may correlate with specific diseases. For example, it is thought that thickening of the muscularis layer may occur secondary to infiltration with neoplastic cells such as lymphoma as opposed to primary changes in the mucosal layer are more commonly associated with inflammatory bowel disease. However, this suspicion needs to be adequately investigated.

The most common types of GI neoplasia seen include LSA, carcinoma (including adenocarcinoma), leiomyosarcoma, leiomyoma, fibrosarcoma, mast cell tumor, hemangiosarcoma and histiocytic sarcoma. Even though there are some tendencies of certain pathology that more often create particular presentations regarding distribution and location of the lesion, histopathologic diagnosis cannot be predicted from the ultrasonographic appearance of the lesions seen.