

# Sonographic Assessment of Intestinal Layering as a Predictor for the Necessity of Enterectomy in Dogs and Cats

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## ABSTRACT

The objective of this retrospective study was to evaluate the positive and negative predictive values (PPV and NPV) of sonographic evidence of intestinal wall layering damage as a predictor for the operative necessity to perform enterectomy in dogs and cats with obstructive intestinal foreign bodies. Forty seven dogs and 5 cats with sonographic evidence of obstructive intestinal foreign bodies were used in this study. Sonographic reports of patients diagnosed with intestinal foreign body and treated surgically, between the years 2013-2018 were reviewed. Subjects were divided into two groups based on the integrity of their intestinal wall layering: Group I were subjects with sonographic loss of intestinal layering (LWL) and Group II were subjects with intact intestinal layering (IWL). Records were reviewed and the surgical procedure was classified as "Enterectomy" or "Enterotomy". Sensitivity, specificity, PPV and NPV of the sonographic evidence of loss of intestinal wall layering were calculated as a predictor for the enterectomy or enterotomy procedure. Enterectomies were performed in 36% (8/35) of the IWL and 89% (15/17) of the LWL cases. The sensitivity and specificity of the sonographic evidence of loss of intestinal wall layering as a predictor of enterectomy were 66% and 94% respectively. PPV calculated to be 89% and NPV 78%. Septic peritonitis was evident in 55% of LWL and 6% of IWL surgeries. It was concluded that sonographic evidence of loss of intestinal wall layering in dogs and cats with intestinal foreign bodies may serve as predictor suggestive for the need to select enterectomy versus enterotomy at the site of the intestine with questionable viability of the intestinal wall. The prevalence of septic peritonitis in cases with sonographic evidence of loss of intestinal wall layering was relatively high. A surgeon experienced with enterectomy techniques will help provide the best prognosis to the patient.

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**Keywords:** Intestinal Foreign Body; Intestinal Wall Layering; Enterotomy; Enterectomy; Intestinal Obstruction.

## INTRODUCTION

Intraluminal intestinal obstruction is one of the most common indications for exploratory laparotomy in dogs and cats, and is most frequently a result of foreign body ingestion (1). Most cases are treated surgically via exploratory laparotomy during which the entire gastrointestinal tract is thoroughly examined. In cases where the bowel is healthy, the foreign object is removed through a longitudinal, anti-mesenteric enterotomy. However, in cases where the intestinal wall is

compromised, the affected area is resected, and an end-to-end anastomosis is performed (2). Enterectomy is considered to be a more challenging procedure and requires superior anatomical knowledge and surgical skills.

Intestinal viability is normally assessed intra-operatively by the presence of peristalsis, evaluation of wall texture, vascular pulsations, and intestinal color (3). However, these subjective assessments do not necessarily correlate with the histologic severity of intestinal damage and outcome (4). Furthermore,

a normal intestinal appearance does not guarantee that the bowel will heal following surgery (4). Several complementary techniques, such as the organic dye fluorescein (5), tissue blood perfusion assessment with the use of Doppler device (6) and surface oximetry measurements (7) were described to allow further assessment of the intestinal viability. However, these techniques are not commonly used in practice due to their inconvenience and variable subjective interpretation. In most cases, the decision to preform enterectomy rather than enterotomy is based on the surgeon's clinical judgment.

Several reports have documented successful sonographic diagnosis of gastrointestinal foreign bodies (8). Ultrasonography was found superior compared to survey radiography as a diagnostic tool for the diagnosis of intestinal foreign bodies (8). For these reasons, abdominal ultrasound scans have become well established and commonly used for the diagnosis of intestinal obstructions. Characteristic sonographic findings in cases of intestinal foreign bodies include the demonstration of the foreign material, acoustic shadowing of the foreign body itself, excessive intestinal distension, fluid accumulation, thickening of the gastrointestinal wall, free peritoneal fluid and loss of intestinal wall layering (8). Loss of intestinal wall layering may be associated with a severe, focal inflammatory process due to regional vascular impairment at the site of the foreign body. This produces severe inflammation and alteration to the intestinal layering (9). Loss of intestinal wall layering was also evaluated among other ultrasonographic parameters in a study involving gastrointestinal perforation (10).

The objective of this study was to evaluate whether sonographic evidence of loss of intestinal wall layering is a good predictor for the necessity to perform enterectomy in cases of obstructive intestinal foreign bodies in dogs and cats.

## MATERIALS AND METHODS

Medical records of 187 subjects presented to a specialty referral hospital, between 2013–2018, with suspected intestinal disease were reviewed.

**Inclusion criteria:** Patients with sonographic diagnosis of obstructing intestinal foreign body confirmed at laparotomy.

**Data and procedure:** Abdominal sonographic scans were performed by either a diagnostic imaging specialist or resident. Subjects were divided into two groups according to the ultrasound report findings: Group I – animals with

sonographic evidence of intestinal wall layering loss (LWL) or group II – cases in which the intestinal wall layering appears to be intact (IWL). The radiologist adopted the mean reference values for the sonographic measurements of the intestinal wall thickness that were previously published for dogs (11) and cats (12) (Table I). LWL was determined when the intestinal layers of the suspected segment could not be clearly differentiated and/or exceeded the described mean reference values (11, 12). (Figures 1-A and B) Intestines were classified as having IWL when all layers (mucosa, submucosa, muscularis and serosa) were demonstrated clearly and did not exceed the described mean reference values (Figures 2-A and B).

**Table I:** Mean reference values for intestinal wall thickness in dogs (Gladwin, Penninck *et al.* 2014) and cats (Goggin, Biller *et al.* 2000).

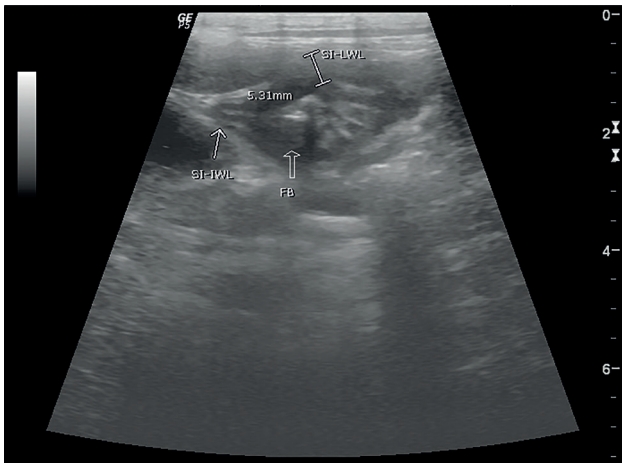
	Duodenum	Jejunum	Ileum	Cecum\Colon
Dog				
<15kg	3.8 mm	3.0 mm	3.0 mm	1.5 mm
15-30kg	4.1 mm	3.5 mm	3.5 mm	1.5 mm
>30kg	4.4 mm	3.8 mm	3.8 mm	1.5 mm
Cat	2.2 mm	2.2 mm	2.8 mm	1.5 mm

Laparotomies were performed by board certified surgeons. Surgical procedures were classified as “Enterectomy” or “Enterotomy”. Signs of peritonitis or abdominal cavity contamination with bowel content were recorded. The decision of the surgeon to perform an enterotomy or enterectomy was based on subjective intraoperative assessment of the affected segments' viability. Criteria such as presence of bowel peristalsis, impaired wall texture, absence of vascular pulsations, dark colorization of the intestinal viscera and the presence of abdominal cavity contamination contributed to performing enterectomy rather than an enterotomy.

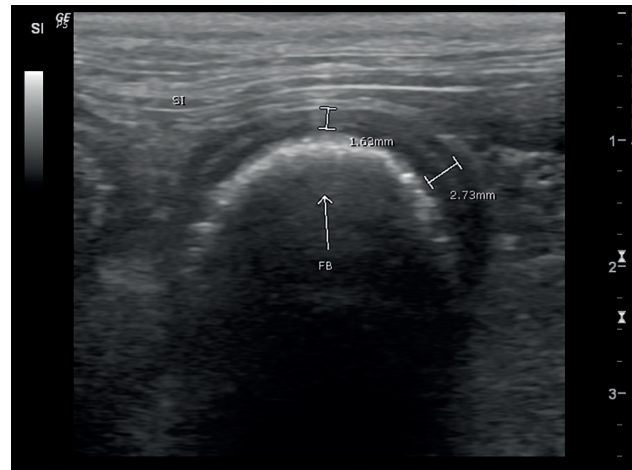
**Data analysis:** Sensitivity, specificity, PPV and NPV of the sonographic evidence of loss of intestinal wall layering as a predictor for the execution of Enterectomy or Enterotomy, were calculated with conventional statistical formulae.

## RESULTS

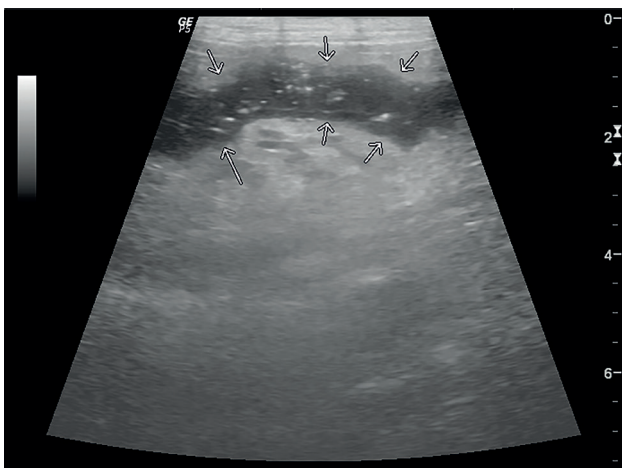
Fifty-two cases (47 dogs and 5 cats) met the inclusion criteria. The median age was 5.5 years (range 1-13) and the median body weight was 25 kg (range 1.8-51 kg). Sonographic LWL was identified in 33% (17/52) of the cases. Of the LWL cases, 89% (15/17) underwent enterectomy, 11% (2/17)



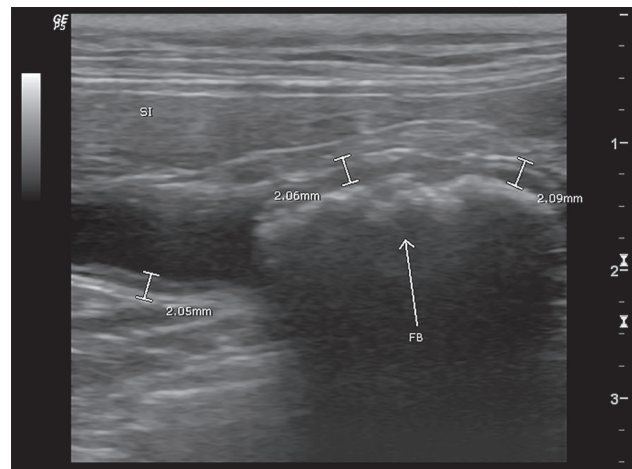
**Figure 1A:** Longitudinal plane image of the small intestine showing normal and distinct intestinal layering (SI-IWL) distal to the lodged foreign body (FB). In comparison, note the altered and thickened (>3mm) intestinal layering at the lodged foreign body site (SI-LWL).



**Figure 2A:** Small intestine (SI) transverse plane image with lodged foreign body (FB) that causing acoustic shadowing and illustrating normal wall thickness (<3mm) and distinct intestinal wall layering.



**Figure 1B:** Longitudinal plane image of the small intestine of the same dog as in Fig 1A showing impaired intestinal layering proximal to the lodged foreign body (FB). Note the hypoechoic intestinal wall and the complete loss of intestinal layering (white arrows) with hyperechoic and reactive surrounding tissue.



**Figure 2B:** Longitudinal plane image through the small intestine of the same dog illustrated in Fig 2A.

of the cases were treated by enterotomy. Sonographic IWL was identified in 67% (35/52) of the cases. 22% (8/35) of which underwent enterectomy and 78% (27/35) cases in which enterotomy was performed (Histogram I).

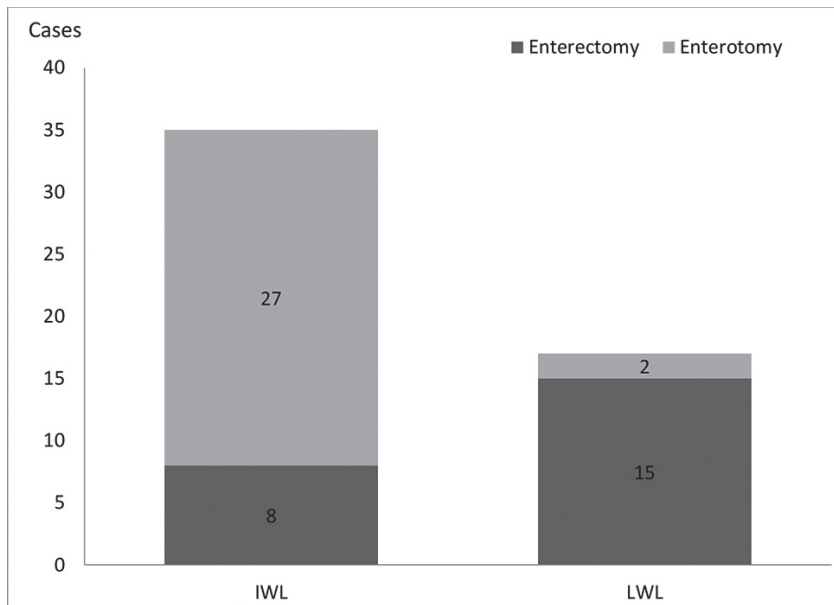
Abdominal peritonitis was evident intra-operatively in 14 cases. Thirteen of the cases were categorized as LWL and underwent enterectomy and, in one case that was categorized as IWL, enterotomy was performed. The overall mortality rate was 9.6% (5/52). Four cases did not recover from the surgery. One case was euthanized per the owners' request due to post-operative poor recovery. Five of 52 of the cases

had to undergo second surgical intervention due to suture dehiscence and secondary peritonitis.

The sensitivity and specificity of the sonographic evidence of loss of intestinal layering as a predictor for the necessity of enterectomy (rather than enterotomy) were 66% and 94% respectively. The calculated positive predictive value of the sonographic LWL as a predictor for the necessity of enterectomy was 89%, and a negative predictive value of 78%.

## DISCUSSION

In this study, we presented 52 cases that had sonographic evidence of obstructive intestinal foreign bodies and underwent enterotomy or enterectomy.



**Histogram I:** Cases of enterectomy and enterotomy within the IWI and LWL groups

In human medicine, ultrasonography has replaced the use of radiographs and contrast studies in the evaluation of gastrointestinal tract conditions (13, 14). A similar trend is taking place in veterinary medicine. Currently, abdominal ultrasonography is widely used in veterinary medicine for the diagnosis of gastrointestinal foreign bodies and considered the modality of choice (15). The consequences of foreign body ingestion depend on the size and shape of the object (16). Linear or small irregular foreign objects may pass uneventfully or cause partial obstruction, whereas large circular foreign bodies usually cause complete obstruction (17). The clinical presentation of an animal with obstruction depends on the foreign body's location, degree of luminal obstruction and alterations to the affected segment's blood flow (15, 17).

Our data demonstrated that the prevalence of intestinal perforation and abdominal cavity contamination in cases of LWL are up to seven times greater than the rate documented in cases of IWL (61%, 8.8% respectively). One third of the cases (17/52) had pre-operative sonographic evidence of LWL. Among those, 89% (15/17) underwent enterectomy, as opposed to only 22% (8/35) of the cases that had IWL. Tidwell *et al.* has shown that proximal obstruction, occurring for a longer duration, causing a greater accumulation of gas versus fluid, would result in a more severe luminal distension and wall tension, leading to inflammatory process and decreased local perfusion (15, 17). Indeed, those cases

are all likely to result in damage to the integrity of intestinal segment's viability seen intra-operatively and to the loss of intestinal wall layering as assessed by pre-operatively ultrasonography.

The sensitivity and specificity of the sonographic evidence of loss of intestinal layering as a predictor for the surgeon's decision to perform enterectomy (rather than enterotomy) were 66% and 94% respectively. The calculated positive predictive value of sonographic LWL as a predictor for the necessity of enterectomy was 89%, and a negative predictive value of 78%. The practical significance of this finding is that the sonographic detection of loss of intestinal layering is highly likely (89%) to require enterectomy. However, in cases that the

sonographic scan reveals no intestinal layer impairment, the operative chances of requiring an enterectomy are relatively low (22%), and, in most cases, enterotomy will be adequate. This fact gives rise to the possibility of relating the ultrasonographic loss of intestinal wall layering as a predictor for the necessity to perform enterectomy rather than enterotomy.

The mortality rate in this study was nearly 10% (5/52). All of the non-survivors were within the LWL group and septic peritonitis was evident during their surgical procedure. Ten percent (5/52) of the cases underwent an additional surgical intervention due to secondary septic peritonitis. The rate of secondary septic peritonitis, in this study, is similar to the reported rate of surgical suture dehiscence (7-16%) (18, 19).

A limitation of this study is that sonographic assessment of wall layering, as well as surgical assessment of intestinal viability are both subjective measurements affected by practical experience. Additionally, the surgeon was exposed to the sonographic findings prior to selecting the surgical strategy, which may have influenced the surgeon's clinical judgment.

Another limitation is the relatively low number (n=52) of subjects, which prevented further statistical analysis differentiating the PPV and NPV between dogs and cats. Despite this fact, in the present study the number of patients was more than double the number of patients in a previous study



that also evaluated intestinal layering in cases of gastrointestinal perforation (10).

Furthermore, in the study mentioned (10), there were only 11 cases of gastrointestinal wall thickening and one patient had an intestinal foreign body. Nine of those eleven cases had intestinal loss of layering compared to our study of 52 cases in which 17 animals had sonographic intestinal loss of layering.

In conclusion, in this retrospective study, the sonographic evidence of loss of intestinal wall layering might serve as a reliable predictor, in conjunction with other clinical parameters, for the necessity to perform enterectomy rather than enterotomy. Furthermore, in cases of sonographic evidence of loss of intestinal wall layering, septic peritonitis is a common finding. These findings offer prognostic information for clients and doctors, and aid in selecting an experienced surgeon.

## REFERENCES

1. Brown, D. C.: *Veterinary Surgery: Small Animal*. K. M. J. Tobias, S.A. Philadelphia, Elsevier Saunders. 2: 1530. 2011.
2. Moore, R. and Carpenter, J.: Intestinal sclerosis with pseudo-obstruction in three dogs. *J. Am. Vet. Med. Assoc.* 184: 830-833, 1984.
3. Walshaw, R.: *The small intestine. General Small Animal Surgery*. R. Walshaw. Philadelphia, JB Lippincott: 343-384, 1985.
4. Brodin, R. E., Semmlow, J.L., Schonanda, A., Koch, R.A., Reddell, M.T., Mast, B.A. and Mackenzie, J.W.: Comparison of five methods of assessment of intestinal viability. *Surg. Gynecol. Obstet.* 168: 6-12, 1989.
5. Lanzafame, R. J., Naim, J.O., Tomkiewicz, Z.M. and Hinshaw, J.R.: The accuracy of predicting intestinal viability with fluorescein: experimental observations. *Curr. Surg.* 40: 292-294, 1983.
6. Mann, A., Fazio, V.W. and Lucas, F.V.: A comparative study of the use of fluorescein and the Doppler device in the determination of intestinal viability. *Surg. Gynecol. Obstet.* 154: 53-55, 1982.
7. DeNobile, J., Guzzetta, P. and Patterson, K.: Pulse oximetry as a means of assessing bowel viability. *J. Surg. Res.* 48: 21-23, 1990.
8. Tyrrell, D. and Beck, C.: Survey of the use of radiography vs. ultrasonography in the investigation of gastrointestinal foreign bodies in small animals. *Vet. Radiol. Ultrasound.* 47: 404-408, 2006.
9. Penninck, D. G.: *Gastrointestinal tract. Small animal diagnostic ultrasound*, 2nd ed. Nyland T.G. and J. S. Mattoon J.S., Philadelphia, W.B. Saunders: 207-230, 2002.
10. Boysen, S. R., Tidwell, A.S. and Penninck, D.G.: Ultrasonographic findings in dogs and cats with gastrointestinal perforation. *Vet. Radiol. Ultrasound.* 44: 556-564, 2005.
11. Gladwin, N.E., Penninck, D.G. and Webster, C.R.: Ultrasonographic evaluation of the thickness of wall layers in the intestinal tract of dogs. *Am. J. Vet. Res.* 75: 349-353, 2014.
12. Goggin, J.M., Biller, D.S., Debey, B.M., Pickar, J.G. and Mason, D.: Ultrasonographic measurement of gastrointestinal wall thickness and the ultrasonographic appearance of the ileocolic region in healthy cats. *J. Am. Anim. Hosp. Assoc.* 36: 224-228, 2002.
13. Berlin, S.C., Goske, M.J., Obuchowski, N., Alexander, F., Zepp, R.C., Goldblum, J.R. and Godec, K.: Small bowel obstruction in rats: diagnostic accuracy of sonography versus radiography. *J. Ultrasound. Med.* 17: 497-504, 1998.
14. Chavhan, G.B., Masrani, S., Thakkar, H., Hanchate, V., Lazar, J., Wasnik, A. and Sunnapwar A.: Sonography in the diagnosis of paediatric gastrointestinal obstruction. *J. Clin. Ultrasound.* 32: 190-199, 2004.
15. Tidwell, A.S. and Penninck, D.G.: Ultrasonography of gastrointestinal foreign bodies. *Vet. Radiol. Ultrasound.* 33: 160-169.
16. Strombeck, D.R. and Guilford, W.G.: *Intestinal obstruction, pseudo-obstruction and foreign bodies. Small animal gastroenterology*, 3rd ed. Guilford, W.G. and Centre, S.A. Philadelphia, W.B. Saunders, 1996.
17. Papazoglou, L.G., Patsikas, M.N. and Rallis, T.S.: Intestinal foreign bodies in dogs and cats. *Compend. Contin. Educ. Pract. Vet.* 25: 830-843, 2003.
18. Allen, D.A., Smrsk, D.D. and Schertel, E.R.: Prevalence of small intestinal dehiscence and associated clinical factors: a retrospective study of 121 dogs. *J. Am. Anim. Hosp. Assoc.* 28: 70-76, 1992.
19. Ralphs, S.C., Jessen, C.R. and Lipowitz, A.J.: Risk factors for leakage following intestinal anastomosis in dogs and cats: 115 cases (1991-2000). *J. Amer. Vet. Med. Assoc.* 223: 73-77, 2003.