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Evaluation of early and systematic ultrasound examination to determine postoperative dehiscence after small intestinal surgery (114 cases in dogs and cats)

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OBJECTIVE
To evaluate the feasibility and reliability of early ultrasound diagnosis for postsurgical bowel dehiscence and find the most reliable ultrasound criteria for dehiscence identification. Additionally, to determine the impact of early ultrasound detection of leakage in terms of survival and duration of hospitalization. Finally, to assess the need for systematized screening or checkup of the population at risk of dehiscence only.

ANIMALS
31 cats and 83 dogs.

METHODS
A retrospective, records-based study was performed on 83 dogs and 31 cats (114 total) undergoing small intestinal surgery. Epidemiologic data, clinical signs, surgical procedures, pre- and postoperative ultrasound findings at 48 to 96 hours, hospitalization duration, complications, and general outcomes were recorded. Univariate and multivariate analyses were used to identify ultrasound findings associated with dehiscence.

RESULTS
Dehiscence was suspected by ultrasound for 0 of 31 cats and 7 of 83 dogs (2 of 49 for enterotomy and 5 of 34 for enterectomy). Every suspected dehiscence was confirmed during revision surgery except one enterectomy revision, which was declined by the owner. Neither this case nor those without ultrasound evidence of dehiscence developed clinical signs of intestinal leakage. Direct visibility of wall discontinuity, presence of gas bubbles, and liquid in vicinity of the intestinal surgical site were statistically associated with early dehiscence. Survival rate after the second surgery was 83%. Median hospitalization time after the second surgery for dehiscence was 2 days (minimum, 2 days; maximum, 4 days).

CLINICAL RELEVANCE
Postoperative ultrasound examination between 48 and 96 hours after intestinal surgery allows early and sensitive detection of intestinal dehiscence. Survival rate after revision surgery was significantly higher than that associated with septic peritonitis.

Keywords: small intestine incisions, bowel dehiscence, ultrasound diagnosis, survival rate, postoperative

Small intestinal surgeries such as enterotomies or enterectomies with intestinal anastomoses are some of the most frequent surgical procedures performed in veterinary medicine. Indications for small intestinal surgery include obstruction by a foreign body, perforation, neoplasia, blunt trauma, and biopsies to investigate various disease processes.[1–6] Complications are relatively infrequent and can be divided into major or minor complications, depending on the prognosis and whether a second surgery is required. The most frequent major complication encountered is suture dehiscence, which is seen in 7% to 15.7% of cases in the veterinary literature.[2,3,6–12] Risk factors for dehiscence include preoperative septic peritonitis,[2,3,6,9,10,13–15] preoperative hypoalbuminemia,[2,3] absence of omentalization,[14] delayed enteral nutrition,[2,14] and anastomosis techniques, such as staple techniques compared to hand sutures.[10,14,16] If not promptly diagnosed and treated surgically, dehiscence can lead to septic peritonitis and, potentially, death. Mortality rates between 15% and 85% after intestinal dehiscence have been reported.[2,6,7,14,17]

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Intestinal healing is divided into several phases.[18–20] First, a platelet aggregate forms and is gradually stabilized by a fibrin clot. In parallel, cell apoptosis associated with the action of collagenases and elastases weakens the strength of the anastomosis to approximately 15% to 50% of the immediate postoperative strength by 2 to 3 days postoperatively.[19,21] During this inflammatory phase, sutures provide the main mechanical support for the intestinal wall; therefore, most dehiscence takes place within 72 to 96 hours postoperatively.[18] The inflammatory phase is followed by a proliferative phase with fibroplasia, during which the strength of the anastomosis increases logarithmically up to 14 days postoperatively.

Postoperative evaluation of intestinal healing is usually based on clinical evaluation, and imaging techniques are rarely used to evaluate postoperative dehiscence. In human medicine, tomography with administration of an oral contrast medium is the gold standard to identify bowel dehiscence.[22] In veterinary medicine, ultrasound is often chosen to evaluate patients in a poor clinical state after surgical anastomosis because of the availability, time efficiency, safety, noninvasiveness, and low cost of this technique. Previous studies[23–25] have used the ultrasonographic assessment of noncomplicated enterotomies and enterectomies to describe the normal appearance of a surgical site during healing. They describe several diagnostic criteria of intestinal dehiscence,[26,27] and the most recent study[27] has also focused on the early detection of intestinal dehiscence by ultrasound. However, these studies only provide an ultrasound description of preoperative bowel breaches and postoperative dehiscence; ultrasound was never assessed as a screening method for an early detection of leakage in an important population of dehiscent and nondehiscent animals. Detecting early signs of dehiscence can lead to early surgical revision before septic peritonitis or other risk factors, such as severe hypoalbuminemia, occur and could improve survival rate. At the Veterinary Specialty Hospital of Languedocia (Montpellier, France), we have used postoperative ultrasound for several years to screen for potential intestinal dehiscence. In our opinion, a good correlation seems to exist between ultrasound recheck and patient outcomes.

The purpose of this study was to assess the diagnostic accuracy of systematic early postoperative ultrasound recheck after enterotomy and enterectomy in dogs and cats. The aims of this study were to describe ultrasound findings during dehiscence, identify the best time point after surgery to perform the ultrasound recheck, and evaluate the effect of systematic ultrasound recheck on duration of hospitalization and patient survival rate.

Methods

Animals

Medical records of all cases that underwent a full-thickness small intestinal incision between July 2017 and December 2021 at the Veterinary Specialty Hospital of Languedocia were retrospectively reviewed. Dogs and cats were included in this study if they had undergone an enterotomy or enterectomy for an intestinal mass, foreign body, diagnostic biopsy, intussusception, stenosis, or blunt trauma, with an ultrasound examination before surgery and an ultrasound recheck between 48 and 96 hours after the initial surgery. Animals were excluded for the following reasons: they presented with a generalized peritonitis before surgery (abdominal effusion–to–blood glucose concentration difference of > 0.2 g/L and lactate concentration difference of > 2 mmol/L, abdominal fluid cytology compatible with septic peritonitis, or intraoperative confirmation of gastrointestinal leakage), they died or were euthanized during surgery, there was no detailed surgical report or no detailed postoperative ultrasound report, or surgery involved the pylorus, major duodenal papilla, or ileocecal valve. A patient with multiple full-thickness small intestinal incisions (eg, for intestinal staging biopsies) was only counted as 1 case. However, a patient treated multiple times with at least 4 months between each surgical procedure (eg, a second foreign body ingestion) was considered as separate cases.

Nonimaging data collection

Both nonimaging and imaging data were extracted from medical records. Nonimaging data included the following: patient characteristics; patient history; clinical signs, CBC, biochemistry, and electrolyte results at presentation; intraoperative data; and, at 15 days, outcomes after surgery. Patient characteristics included species (cat or dog), breed, sex, age, body weight, and body condition score (1 to 5). Patient history included duration of clinical signs and presence of vomiting, diarrhea, anorexia, weight loss, and lethargy. Clinical signs at presentation included the degree of dehydration (5% if dry mucosa, 8% if persistent skinfold, 10% if endophthalmia, and 14% if neurologic signs), presence or absence of hyperthermia (rectal temperature higher than 39.2 °C [102.5 °F]), and abdominal palpation findings (eg, pain, discomfort, mass sensation). Blood analysis data included leukocyte, RBC, and platelet cell count; total protein; albumin; glucose; hepatic enzymes (ALP); renal parameters (urea and creatinine); and measurement of electrolyte concentrations (sodium, potassium, and chloride) in cases of vomiting. Intraoperative data included surgical indication, type of surgery performed (enterotomy or enterectomy), number and location (duodenum, jejunum, or ileum) of full-thickness small intestinal incisions, type of suture pattern (simple interrupted, continuous, or staple device), and size of suture material. We also collected data on any concurrent surgical procedures, such as gastrotomy, nephrectomy, or extraintestinal biopsies, and the results of any histopathologic analysis. Postoperative data included occurrence of intestinal dehiscence, duration of hospitalization, survival rate at discharge, and survival rate 2 weeks after surgery.

Imaging data collection

General considerations

Pre- and postoperative ultrasound examinations were performed by a board-certified veterinary radiologist or a resident in veterinary imaging under diplomate supervision with an Affiniti 50 or EPIQ Elite ultrasound machine (Koninklijke Philips NV) fitted with a microconvex transducer and high-frequency linear transducers with a frequency range from 4 to 18 MHz and ultrabroadband frequencies up to 22 MHz. The screening postoperative ultrasound examinations were performed at a minimum of 48 hours postoperatively and maximum of 96 hours postoperatively; timing was adjusted to accommodate after-hours schedules and weekends.

The transducer frequency was adjusted to the highest level allowed by the depth of the examined structures to maximize the accuracy of the assessment. Preoperative sonographic examinations were performed on an emergency basis, and food was not withheld, unlike the postoperative screening ultrasound examinations for which food was withheld the night before. Postoperative images were systematically compared to the preoperative ones.

Postoperative ultrasound evaluation

The postoperative ultrasound reports of each case were retrospectively reviewed by a European College of Veterinary Surgeons specialist (EG), radiologist (CBT), and radiology resident (CS). For most patients, the imaging studies were lost due to technical issues and only the imaging reports were reviewed. The reviewers of the reports were not blinded to the surgical findings and outcomes. The presence or absence of each ultrasound feature was recorded for statistical analysis.

Seven ultrasound criteria were evaluated to best describe the surgical site and classify it as dehiscent **(Figure 1)** or not dehiscent **(Figure 2)**. Six of them were previously described in the studies of Matthews et al[24] and Costanzo et al.[27]

Intestinal wall thickness is evaluated from a transverse section of the intestine at the surgical site at its thickest bridge. The wall thickness of the surgical site was compared with the wall thickness oral and aboral to the surgical site. The reduced or absent wall layering of the intestine (ie, the ability to clearly distinguish each of the layers of the intestinal wall from serosa to mucosa with ultrasound) was noted if present.

Steatitis is defined as hyperechogenicity of abdominal fat. The entire abdominal fat was visualized, but the fat surrounding the surgical site was scrutinized with particular attention and subjectively assessed as hyperechogenic or not.

Intestinal peristalsis is observed from the stomach to the aboral part of the ileum. The gastrointestinal tract was subjectively evaluated to determine the presence or absence of an ileus, characterized by a distension of intestinal loop by digestive content with variable peristalsis. Corrugated segments of small intestine at and adjacent to the surgical site were also noted as present or absent.

The local effusion at the surgical site is visualized as a clear area with an irregular contour, anechoic to hypoechoic, in direct contact with the surgical site. The effusion is measured at its widest point in order to be able to perform a dynamic follow-up during a subsequent ultrasound if necessary, but only the presence or absence of local effusion was evaluated in this work. This feature was reported to be rather present on a dehiscent site.

Gas bubbles and suture/staples both appeared as hyperechoic foci within the intestinal wall. Gas bubbles were suspected when hyperechoic foci were irregularly spaced/discontinuous and had associated reverberation artifacts. Suture/staples were suspected when hyperechoic foci were regularly spaced and/or continuous and lacked reverberation artifacts. If hyperechoic foci with reverberation artifacts crossed the entire wall at the intestinal anastomosis site, we noted that feature as "gas within the wall," which is a sign of dehiscence and not reported with a normal surgical site.

The last parameter, reported in Penninck and d'Anjou's textbook[28] but not reported in other publications for the diagnosis of postoperative intestinal suture dehiscence, was the direct visualization of intestinal wall discontinuity, which is characterized by a spacing between the 2 sides of the surgical site, variable in shape and size, occupied by digestive content. In 4 cases, the presence or absence of this feature was not specified in the reports due to the radiologist's uncertainty; the statistical analysis focused only on the 110 cases in which the criterion was reported.

During the ultrasound examination, the pancreas was simultaneously evaluated for signs of pancreatitis such as lymph node abnormalities.

When the surgical site was identified and each of the previously described parameters were evaluated, a final conclusion was made by the radiologist who performed the examination. The identification of a normal surgical site was commonly based on the presence of focal wall thickening with reduced or loss of the wall layering, within which hyperechoic foci were visible, usually corresponding to the sutures and frequently surrounded by hyperechoic fatty tissue.

When the surgical site could not be identified, there was an intermediary amount of fluid, gas could not be differentiated from the sutures, or a wall discontinuity was suspected but not confirmed, the cases were characterized as doubtful and the ultrasound examination was repeated 24 hours later to assess the evolution of the findings. When a second ultrasound examination was necessary, only the features observed during the second examination were used in this study because the decision to perform a revision surgery was based on this second examination.

The definitive diagnosis of intestinal leakage was founded on intraoperative findings. Since dehiscence of the intestinal sutures occurs within a few days postoperatively, all animals considered healthy at the recheck 15 days after surgery were considered nondehiscent.

Statistical analysis

For nonimaging data, univariate analysis was used to detect any significative difference in the

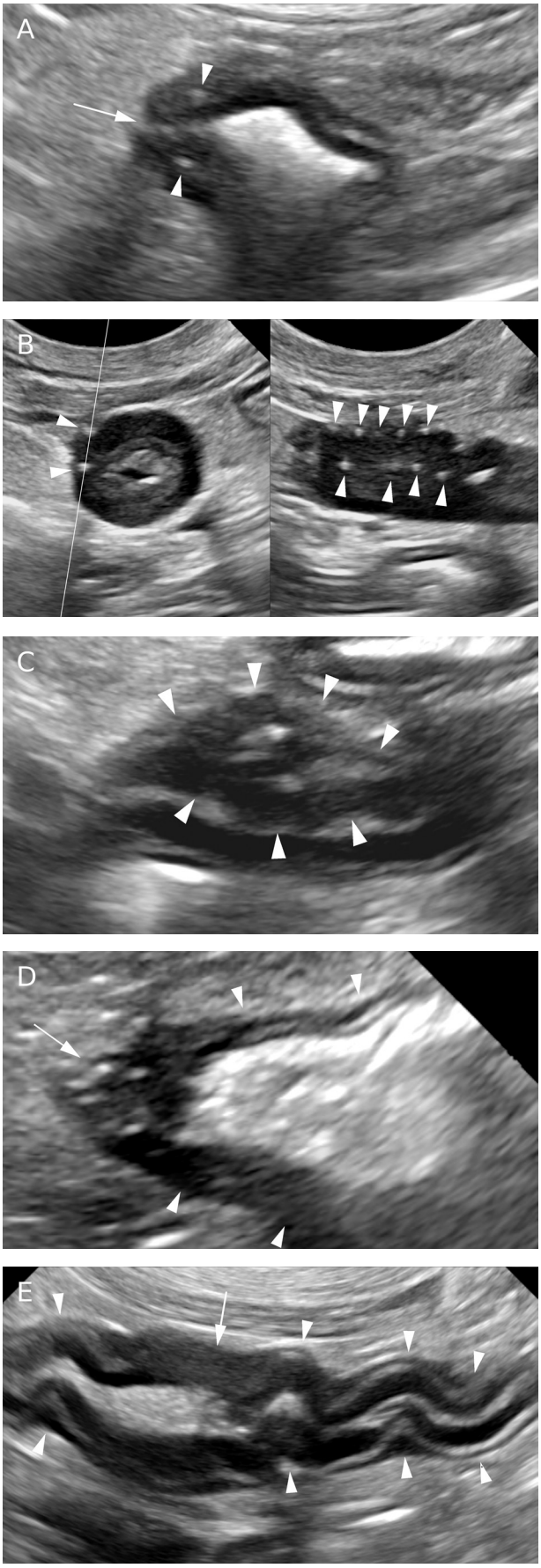

Figure 1—Imaging features seen in patients classified as nondehiscent. A—Transverse ultrasonographic image of an enterotomy site without evidence of dehiscence 48 hours postoperatively in a 3-year-old Maine Coon cat. The enterotomy site appears as a discrete focal hypoechoic thickening with loss of layer definition of the small intestinal wall, with thin hyperechoic tract (arrow) representing the incision area and symmetrically disposed hyperechoic punctuations (arrowheads) representing sutures. EPIQ (Koninklijke Philips NV), microconvex transducer. B—Transverse (left) and longitudinal (right) images of an enterotomy site without evidence of dehiscence 48 hours postoperatively in a 2-year-old European Shorthair cat. The enterotomy site appears in the transverse image as a moderate circumferential thickening with incomplete loss of layer definition of the small intestinal wall and hyperechoic punctuations (arrowheads) representing sutures. The enterotomy site appears in the longitudinal image as a hypoechoic band with regularly disposed hyperechoic punctuation (arrowheads) representing sutures at the level of the line seen on the left image. EPIQ, microconvex transducer. C—Longitudinal ultrasonographic image of an enterotomy site without evidence of dehiscence 72 hours postoperatively in a 4-year-old White Swiss Shepherd Dog. At the enterotomy site, there is a focal and marked thickening of the small intestinal wall with irregular borders (arrowheads). Discrete to moderate steatitis is visible in the surrounding fat. EPIQ, microconvex transducer. D—Ultrasonographic image of an enterotomy site without evidence of dehiscence 48 hours postoperatively in a 2-year-old European Shorthair cat. An ileus (arrowheads) is visible at the level of the enterotomy site (arrow). Discrete steatitis is noted in the surrounding fat. EPIQ, high-frequency linear transducer. E—Longitudinal ultrasonographic image of an enterotomy site without evidence of dehiscence 48 hours postoperatively in a 3-year-old Maine Coon cat. The small intestinal wall is corrugated (arrowheads) on both sides of the enterotomy site (arrow). Discrete to moderate steatitis is noted in the surrounding fat. EPIQ, microconvex transducer.

study population and identify risk factors of dehiscence. If a second postoperative ultrasonography was performed because of a first doubtful result, only the data from the second one were used for statistical analysis. All continuous variables were described with median, mean, and SD. Fisher exact and χ^2 tests were performed on nominal qualitative data, and all hypothesis tests were 2-sided with the significance level set at $\alpha < .05$. Missing data were left as missing (ie, not imputed). Commercially available software was used for all analyses (R Studio, version 4.2.2; The R Foundation for Statistical Computing).

Results

Preoperative clinical findings

A total of 114 cases (31 cats and 83 dogs) were included in this study. The median age of the cats was 4.7 ± 3.8 years (range, 0.5 to 14 years). The median body weight of the cats was 4.4 ± 1.75 kg (range, 2 to 7.5 kg). There were 20 males and 11 females (sex ratio, 1.81), and the most common breeds were domestic shorthair (n = 19) and Maine Coon (7). The median age of the dogs was 5.5 ± 3 years (range, 0.2 to 15.5 years). The median body weight of the dogs was 22.9 ± 10.6 kg (range, 2.5 to 57 kg). The were 42 males and 41 females (sex ratio, 1.02), and the most common

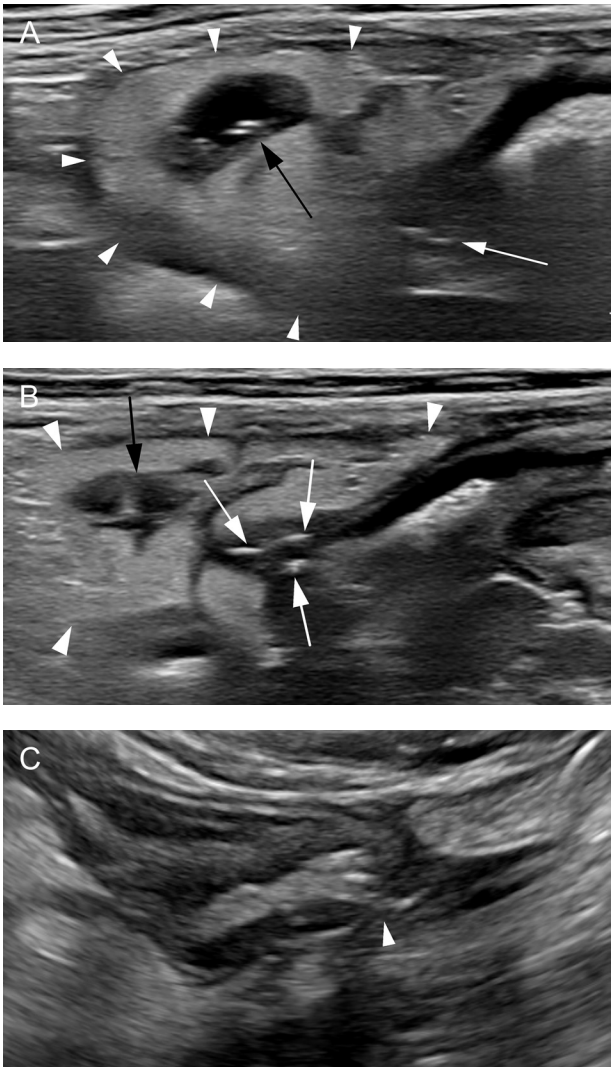

Figure 2—Imaging features seen in patients classified as dehiscent. A—Ultrasonographic image of the area adjacent to an enterotomy site with suspected dehiscence 72 hours postoperatively in a 1-year-old female crossbreed dog. Marked steatitis (arrowheads) is noted in the surrounding fat with loculated hypoechoic fluid containing gas bubbles (black arrow) at the level of the enterotomy site (white arrow). The latter is more conspicuous in panel B. EPIQ, high-frequency linear transducer. B—Ultrasonographic image of the same dog as panel A at the level of an enterotomy site with suspected dehiscence 72 hours postoperatively. The tract of the incision site is enlarged, and gas bubbles are visible inside (white arrows). Marked steatitis (arrowheads) in the surrounding fat with loculated hypoechoic fluid (black arrow) is still visible. Further controls had shown an amelioration of these findings, and a conservative treatment was decided with good outcomes. EPIQ, high frequency linear transducer. C—Transverse ultrasonographic image of an enterotomy site with evidence of dehiscence 72 hours postoperatively in a 2-year-old female Akita Inu. The tract of the incision site is discretely enlarged, and material with features similar to digestive content is visible inside, extending into the adjacent tissue (arrowhead), indicating a direct observation of wall discontinuity. At this level, this material is surrounded by a hypo- to anechoic area probably representing inflammatory tissue and fluid. Moderate steatitis is visible in the surrounding fat. A surgical revision had confirmed the presence of dehiscence. EPIQ, high-frequency linear transducer.

dog breeds were Jack Russell Terrier (n = 8), Belgian Malinois (6), and Staffordshire Bull Terrier (4).

The most frequent clinical signs were vomiting (95 of 114 cases [83.3%]), reduced appetite (73 of 114 cases [64.0%]), lethargy (72 of 114 cases [63.2%]), weight loss (28 of 114 cases [24.6%]), and diarrhea (26 of 114 cases [22.8%]). The average duration of clinical signs was highly variable and ranged from 1 day to 4.1 years, with a median duration of 46 ± 67 days. However, 70% of cases had shown clinical signs for < 1 week. The main blood test abnormalities were neutrophilic leukocytosis (36 of 114 cases [31.6%]), anemia (8 of 114 cases [7.0%]), and neutropenia (2 of 114 cases [1.8%]). Electrolyte disorders included hypochloremia (23 of 114 cases [20.2%]), hyponatremia (21 of 114 cases [18.4%]), hypokalemia (14 of 114 cases [12.3%]), and hyperkalemia (1 of 114 cases [0.9%]). Hypoalbuminemia was observed in 8 of 114 cases (7.0%).

Initial surgical findings

Of the 114 cases, 72 underwent enterotomies (23 cats and 49 dogs) and 42 underwent enterectomies (8 cats and 34 dogs). The most common indications were foreign body removal and mass excision **(Table 1)**. In total, 141 full-thickness small intestinal incisions were made, including 21 duodenal incisions, 105 jejunal incisions, and 15 ileal incisions. Concurrent procedures were uncommon and included gastrotomy (n = 17), liver or pancreatic biopsies (6), and nephrectomy (1).

Closure was achieved by use of an automated stapling device in 5 cases (thoracoabdominal, gastrointestinal anastomosis), continuous suture pattern in 67 cases, or interrupted pattern in 69 cases. Polydioxanone and Glycomer 631 (Biosyn; Medtronic PLC), sizes 3-0 and 4-0, were used for handed sutures.

Postoperative imaging

Each patient underwent a screening ultrasound examination performed by a board-certified veterinary radiologist or a resident in veterinary imaging between 48 and 72 hours postoperatively (87 of 114 cases) or between 72 and 96 hours postoperatively (27 of 114 cases). During the examination, the surgical sites could be visualized and assessed in 100% (42 of 42) of the cases of intestinal anastomosis and 96% (69 of 72) of the cases of enterotomy.

In 19 of the 114 cases, clinicians were uncertain about dehiscence and thus repeated the ultrasound examination 24 hours later. Of these 19 patients, 14 were examined by ultrasound 48 hours postoperatively and underwent a second examination 72 hours postoperatively. The other 5 underwent a first examination 72 hours postoperatively and a second examination 96 hours postoperatively.

In 3 of 114 cases, the surgical site was not found on postoperative ultrasound. Evaluation criteria applicable to the whole small intestine (ileus, steatitis, and corrugation of the intestinal loops) were used to classify these cases. All 3 were classified as nondehiscent.

Seven of the 83 dogs were finally suspected of intestinal dehiscence; 4 were suspected 48 hours

Table 1—Indications of full-thickness small intestinal incisions in cat and dog populations. Enterotomies performed for foreign body removal represent the main procedure in both populations.

	Foreign body	Mass	Intussusception	Traumatic perforation	Biopsies	Stenosis
Cats (n = 31)						
23 enterotomy	20	—	1	1	1	—
8 anastomosis	1	5	1	—	—	1
Dogs (n = 83)						
49 enterotomy	42	—	—	1	6	—
34 anastomosis	17	15	1	1	—	—

— = Not applicable.

postoperatively and 3 between 72 and 96 hours postoperatively. Dehiscence was not suspected in any of the cats included in this study.

Second surgical findings

Six out of 7 patients with suspected dehiscence underwent a revision surgery, which each time confirmed leakage at the surgical site. In these cases, a new reinforcement suture was placed, a massive peritoneal lavage was performed, and a serous or omental patch was applied according to the surgeon's assessment. One additional case suspected of dehiscence was identified by ultrasound, but revision surgery was declined by the patient's owner.

Confirmed intestinal leakage (dehiscence) occurred only in dogs, 4 of 6 in the jejunum and 2 of 6 in the duodenum. Of the 6 dogs that experienced dehiscence, 5 had undergone surgical foreign body removal and 1 had undergone intestinal mass excision. These cases included 4 enterectomies and 2 enterotomies.

Outcome

One of the 6 patients that had dehiscence died 3 days after the revision surgery following a sudden clinical deterioration. The other 5 were discharged from hospital in the days following the second operation. Survival rate after revision surgery was therefore 83% (5 of 6 dogs).

The additional patient with suspected dehiscence by ultrasound for which revision surgery was declined by the owner survived and was in a good general clinical condition 6 days after surgery. Furthermore, all 107 patients in which dehiscence was not suspected on ultrasound examination survived; therefore, the overall survival rate was 99.1%. The median hospitalization time was 2 days. For the nondehiscent population, the median hospitalization time was 2 days (minimum, 2 days; maximum, 3 days). For the dehiscent population, the median hospitalization time was 3.5 days (minimum, 3 days; maximum, 4 days).

No significant difference between the dehiscent and nondehiscent groups was observed (P = .117). There were also no statistically significant differences between the dogs that experienced dehiscence and those that did not in terms of age (P = .653), body weight (P = .158), sex (P = .894), breed (P = .451), electrolyte disorders (P = .093), concurrent surgical procedures (P = 1), the size of the sutures used (P = .784), or the closure method used (continuous suture pattern, interrupted suture pattern, or staple device; P = .847). There was also no significant difference in the rate of dehiscence in cases of intestinal mass excision (1 of 20 cases [5%]) and cases of foreign body removal (5 of 80 cases [6%]) (P = .67). Even if the risk of dehiscence was higher in the enterectomy group (4 of 42) than in the enterotomy group (2 of 72), this did not reach statistical significance (P = .19). However, the presence of preoperative hypoalbuminemia was significantly associated with a higher risk of intestinal leakage. Hypoalbuminemia was found in 3 of 6 cases (50%) of dehiscence and 5 of 108 cases (4.6%) without dehiscence (P = .013).

Postoperative ultrasound analysis

As previously described, the combination of imaging features we typically saw in our patients without dehiscence included the following: focal thickening of the wall with reduced or absent wall layering, regularly spaced hyperechoic foci (consistent with staples and sutures) without gas in the wall or local effusion, focal hyperechoic fat (consistent with steatitis/edema), and minimal or absent ileus or intestinal loop corrugation. These patients presented no sign of direct intestinal wall discontinuity.

Imaging features overlapped in patients with dehiscence, including focal wall thickening and reduced or loss of wall layering. Ileus and intestinal loop corrugation were also encountered, often more marked for the latter. In contrast, features consistent with dehiscence included a spacing between the 2 sides of the surgical site, variable in shape and size, occupied by digestive content, possibly gaseous or partially gaseous, consistent with intestinal wall discontinuity. Additionally, patients with suspected dehiscence had severe surrounding hyperechoic fat (consistent with steatitis or edema) and loculated fluid with or without gas bubbles.

Table 2 shows the numbers of patients presenting and not presenting the assessed ultrasound criteria among the dehiscent and nondehiscent groups. Parietal thickening, ileus, and plication of the intestinal loops were frequently present within both the dehiscent and nondehiscent groups. On the contrary, the absence of steatitis or local effusion seemed to be a good predictor of an uncomplicated evolution.

Table 3 shows the sensitivity, specificity, positive predictive value, and negative predictive value for each parameter individually. The criterion "direct visibility of intestinal wall discontinuity" (Figure 2) allowed an excellent assessment of the surgical site with a sensitivity and specificity of 100%. In the 3

Table 2—Ultrasonographic feature findings observed during the postoperative screening ultrasound examination after intestinal surgery.

	Loop corrugation		Gas bubbles within the wall		Steatitis		Direct visibility of a discontinuity		Local effusion		Ileus		Wall thickening	
	+	–	+	–	+	–	+	–	+	–	+	–	+	–
Dehiscent population	3	3	4	2	6	0	5	0	6	0	4	2	5	1
Nondehiscent population	19	89	7	101	89	19	0	105	19	89	29	79	86	22

A plus sign (+) indicates the presence of the feature. A minus sign (–) indicates the absence of the feature.

Table 3—Statistical analysis of seven ultrasound criteria monitored during the early postoperative ultrasound recheck after small intestine surgery shows that "gas bubbles within the wall" and "local effusion" are the most significant criteria reliable to detect an intestinal leakage.

	Loop corrugation	Gas bubbles within the wall*	Steatitis	Direct visibility of a discontinuity*	Local effusion*	Ileus*	Wall thickening
Sensitivity (%)	50	66.7	100	100	100	66.7	16.7
Specificity (%)	82.4	93.5	17.6	100	82.4	73.2	88.6
PPV	13.6	36.4	6.3	100	24	12.1	7.1
NPV	96.7	98	100	100	100	97.6	95.3
χ^2	3.83	23.62	1.27	110	22.6	4.38	0.15
P value	> .05	< .001	> .05	< .001	< .001	< .05	> .05

NPV = Negative predictive value. PPV = Positive predictive value.
*Feature statistically associated with dehiscence.

Table 4—Statistical analysis of different criteria associations showing the decreasing of sensitivity and increasing of specificity associated with their respective PPV and NPV to detect an intestinal leakage with 2 to 5 ultrasound criteria monitored during the early postoperative ultrasound recheck after small intestinal surgery.

	No. of ultrasound criteria considered			
	2 parameters	3 parameters	4 parameters	5 parameters
Sensitivity (%)	100	100	100	66.7
Specificity (%)	45.4	83.3	94.4	98.2
PPV	9.2	25	50	66.7
NPV	100	100	100	98.2

cases of enterotomy where the sutures were not observed during ultrasound examination, this criterion could not be assessed. The 2 other most significant criteria associated with dehiscence were the presence of gas bubbles within the wall and the presence of a local effusion ($P < .001$), with a sensitivity of 66.7 and 100, respectively, and specificity of 93.5 and 82.4, respectively.

Table 4 shows a significant decrease in sensitivity and increase in specificity of the ultrasound examination for the detection of dehiscence when multiple criteria were identified. The best positive predictive value (66.7%) was found with the combination of 5 parameters and associated with a high negative predictive value (98.2%).

Discussion

The results of this study show that early ultrasound diagnosis of intestinal dehiscence is feasible. The identification of the surgical sutures or staples during ultrasound examination was possible in a majority of the patients (111 of 114 [97%]), with a more important proportion of intestinal anastomosis sites visible (100%) than enterotomy sites (96%). This difference is likely due to the circumferential distribution and comparatively larger size of the surgical site in cases of enterectomy. Enterotomy sites are linear and performed on the antimesenteric side of the bowel surface, making them more difficult to observe. These data are higher than a previous study,[24] in which 76% (19 of 25) of intestinal surgical sites were visualized with screening ultrasound examination. In the population of that study, 11 of 11 enterectomy sites (100%) and 8 of 14 enterotomy sites (57%) were finally visualized postoperatively with sequential ultrasound examinations (postoperative days 1, 3, 6, 10, and 20). While pneumoperitoneum is not a major concern for visibility of intra-abdominal surgical sites,[24] it is still recommended that surgeons make every effort to surgically remove the rinsing liquid and remaining air when closing the abdominal wall to facilitate the ultrasound recheck.

When the surgical site could not be found by ultrasound postoperatively (3 of 114 cases [2.6%]), the direct visibility of sutures could not be assessed. However, the overall ultrasound assessment allowed us to classify these cases as nondehiscent. It is likely that ultrasound abnormalities suggestive of dehiscence make the surgical site more visible. It can therefore be reasonably assumed that surgical sites not detected by ultrasound are at low risk of dehiscence.

Ultrasound evaluation of the normal evolution of an enterotomy wound during the different phases of healing has already been described,[23–25] as well as diagnostic criteria of intestinal dehiscence.[26,27] Unfortunately, some ultrasound features are found similarly during uncomplicated postoperative courses and in

cases of dehiscence such as pneumoperitoneum, corpuscular abdominal effusion, or small fluid collections.[23,27] Based on previously reported ultrasound features,[26,27] we used 6 qualitative ultrasound criteria in this study: gas bubbles within the wall, intestinal wall thickening at the surgical site, local effusion, steatitis in the tissues surrounding the surgical site, intestinal loop corrugation, and ileus oral and aboral to the surgical site to conduct an objective evaluation of the surgical site. We chose to add a seventh feature not previously reported in a postoperative intestinal examination: the direct visibility of a wall discontinuity. In our study, we found that the ultrasound diagnosis of intestinal dehiscence had a sensitivity and a specificity of 100% if the surgical site could be visualized and a sensitivity and specificity of up to 66.7% and 98.2%, respectively, if it could not. All cases of dehiscence identified with ultrasound were confirmed during surgical revision, except 1 for which it was declined by the owner, and no case in which dehiscence was not suspected died following the procedure. However, the positive predictive value remained moderate (66.7% or less), even in the presence of 4 or 5 ultrasound criteria, due to the low prevalence of intestinal dehiscence in our study population. In contrast, the negative predictive value was between 98.2% and 100%, suggesting that the ultrasound parameters used in this study can predict the absence of dehiscence. The parameters showing a high individual sensitivity and specificity were gas bubbles within the wall and local effusion. Imaging findings from our current study were in accordance with the recent study of Costanzo,[27] in which these 2 features have been documented in 11 cases of intestinal suture dehiscence. In our study, we studied a characteristic of the surgical site not reported in clinical studies about postoperative intestinal dehiscence. Direct visibility of intestinal wall discontinuity is 100% sensitive and specific in the data of this study.

In the dehiscent population, 3 cases were diagnosed with a screening ultrasound examination between 48 and 72 hours postoperatively and 3 between 72 and 96 hours postoperatively. Unfortunately, considering the low number of dehiscent cases, the data didn't allow us to decide the best timing to perform the ultrasound control. In cases where ultrasound findings are equivocal, ultrasound examination should be repeated 24 hours later (19 of 114 cases in our population). It is for this reason that we advise to perform the first ultrasound 48 to 72 hours postoperatively. Given the excellent negative predictive value in our study, if no obvious sign of dehiscence is identified on the first ultrasound, patients can be discharged immediately after the ultrasound with relative serenity. If there is any doubt, patients should remain in hospital to repeat ultrasound after 24 hours.

The mortality rate after revision surgery in this study was 16.6% (1 of 6), compared with the 15% to 85% mortality rate reported in cases of septic peritonitis.[2,6,7,14] We believe these good outcomes were due to the fact that the peritonitis remained local in the cases that required revision surgery. Severe hyperthermia, hypotension, and marked lethargy were not yet present; therefore, the animals were more prone to undergo a second surgery with lower anesthetic and surgical risk. These data suggest that the time taken to identify a postoperative dehiscence may be a critical parameter affecting animal survival. Early identification of intestinal dehiscence is more likely to lead to successful surgical revision, while a delayed diagnosis could potentially lead to the development of generalized peritonitis.[29] In a previously published study[2] of 90 dogs with full-thickness bowel wall incisions, 14% developed dehiscence and, of these, 85% died despite revision surgery. The mean time to detection of dehiscence in that study was 5 postoperative days (range, 3 to 10 days). In contrast, in our study, the mean time between the first intervention and the revision surgery was 3 days (range, 2 to 4 days). We hypothesized that this was one of the main reasons for the low mortality rate after surgical revision (16.6%) and, therefore, the low overall mortality rate (0.9%) in our study. This short delay probably resulted from the early detection of dehiscence by ultrasound.

We identified 1 case of suspected dehiscence on ultrasound in which revision surgery was declined by the owner. This dog had a good clinical postoperative outcome. Therefore, it was not clear whether the ultrasound findings represented a false positive or whether this dog had a small dehiscence that remained subclinical. There are a number of reports[30–33] of intestinal wall disruption that were not treated surgically but in which an omental patch sufficiently sealed the deficit to prevent fulminant peritonitis and allowed complete healing of the intestinal wall. However, in view of the major risk of mortality associated with septic peritonitis, it seems more appropriate to treat any postsurgical intestinal leakage with revision surgery. This case also raises the question of the possibility that some dehiscence might be missed on ultrasound examination, as all 107 cases in which dehiscence was not suspected survived and had neither a surgical recheck nor a postmortem examination to corroborate the absence of dehiscence. Anyway, if a small breach was potentially present, it was not life-threatening. As animal survival is the finality of the ultrasound recheck, this finding indicated that our dehiscence criteria seemed to be adequate.

The best way to miss as few cases of dehiscence as possible is to screen all animals; but, given the overall low rate of dehiscence of digestive sutures,[27] it may be possible to perform postoperative ultrasound screening only in animals most at risk. Therefore, it is essential to identify risk factors for dehiscence in order to guide patient selection for ultrasound screening. In our study, the risk of dehiscence was higher in the enterectomy group (4 of 42) than in the enterotomy group (2 of 72), but this did not reach statistical significance (P = .19). Hypoalbuminemia (< 25 g/L) is another important risk factor for suture dehiscence, as albumin is an important marker of the body's ability to ensure an effective inflammatory phase of healing.[34] In human medicine, albumin concentration is considered a

highly sensitive indicator of preclinical disease and disease severity and a 2.5-g/L reduction in serum albumin concentration is associated with an increase in the risk of death from 24% to 56%.[35] In the future, early biomarkers of dehiscence such as C-reactive protein could be assessed in veterinary medicine. In our study, hypoalbuminemia was observed in 3 of 6 cases (50%) of dehiscence and 5 of 108 cases (4%) without dehiscence (P = .013).

Foreign body removal has also been described as a risk factor for dehiscence.[2,3,6,16] However, in our study, we saw no significant difference in the rate of dehiscence in cases of intestinal mass excision and cases of foreign body removal (P = .67). Furthermore, we did not observe dehiscence in any of the cats included in our study, which supports data from other studies showing that cats have a much lower risk of postoperative intestinal breach than dogs.[2,5,27] Therefore, postoperative ultrasound screening may be of less interest in cats.

A previous study[2] developed a model for predicting dehiscence that was 84% accurate. The model was defined as the presence of at least 2 of the 3 following risk factors: preoperative septic peritonitis, hypoalbuminemia (< 25 g/L), and presence of foreign body.[2] The positive predictive value of this model was low (46%), but the negative predictive value was high (98%). We could not apply this model to our study because we excluded patients with preoperative septic peritonitis. However, considering the high negative predictive value of the model, it may be appropriate to perform postoperative screening ultrasound in patients presenting with at least 2 of these 3 risk factors. That study was conducted only on a population of dogs that underwent an enterectomy and, therefore, these data may not be applicable to other patient populations. Furthermore, animals with intestinal obstruction often present with dehydration and hemoconcentration, which can lead to an overestimation of serum albumin. Lastly, adopting a policy of only performing ultrasound screening on the cases most at risk of dehiscence may lead to missed early dehiscence diagnosis.

Our study had several limitations. It was a single-center, retrospective study, and the rate of dehiscence was low in our patient population, which had an impact on the statistical power of the study. Most of the ultrasound criteria used were evaluated qualitatively and not quantitatively, which facilitated the data proceeding to the detriment of the accuracy. Furthermore, an important part of images was lost due to a technical issue and only the imaging reports were reviewed. In rare cases, the presence or absence of direct visibility of a discontinuity was not specified in the reports. Moreover, postoperative ultrasound reports were not reread blindly. The reliability of the ultrasound diagnosis is highly dependent on the skill and learning curve of the echographer and performance of the material. A loculated fluid analysis wasn't systematically performed to discriminate between inflammatory and septic effusion because of the very modest quantity and difficulty to puncture it. Moreover, we did not investigate the correlation between ultrasound signs of dehiscence and postoperative clinical signs due to the lack of information about postoperative clinical evolution. In our clinical experience, ultrasound abnormalities precede the appearance of clinical signs related to intestinal dehiscence and that this is the major advantage of performing ultrasound screening after intestinal surgery, but this statement couldn't be evaluated.

In conclusion, our data show that postoperative ultrasound examination between 48 and 96 hours after intestinal surgery allows early and sensitive detection of intestinal absence of dehiscence. This allowed us to achieve a survival rate after revision surgery that was significantly higher than that associated with septic peritonitis.

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References

1. Wylie KB, Hosgood GH. Mortality and morbidity of small and large intestinal surgery in dogs and cats: 74 cases (1980–1992). *J Am Anim Hosp Assoc*. 1994;30:469–474.
2. Ralphs SC, Jessen CR, Lipowitz AJ. Risk factors for leakage following intestinal anastomosis in dogs and cats: 115 cases (1991–2000). *J Am Vet Med Assoc*. 2003;223(1):73–77. doi:10.2460/javma.2003.223.73
3. Grimes JA, Schmiedt CW, Cornell KK, Radlinksy MAG. Identification of risk factors for septic peritonitis and failure to survive following gastrointestinal surgery in dogs. *J Am Vet Med Assoc.* 2011;238(4):486–494. doi:10.2460/javma.238.4.486
4. Strelchik A, Coleman MC, Scharf VF, Stoneburner RM, Thieman Mankin KM. Intestinal incisional dehiscence rate following enterotomy for foreign body removal in 247 dogs. *J Am Vet Med Assoc*. 2019;255(6):695–699. doi:10.2460/javma.255.6.695
5. Hiebert EC, Barry SL, Sawyere DM, DeMonaco SM, Muro NM. Intestinal dehiscence and mortality in cats undergoing gastrointestinal surgery. *J Feline Med Surg*. 2022;24(8):779–786. doi:10.1177/1098612X211048454
6. Allen DA, Smeak DD, Schertel ER. Prevalence of small intestinal dehiscence and associated clinical factors: a retrospective study of 121 dogs. *J Am Anim Hosp Assoc*. 1992;28(1):70–76.
7. Jardel N, Hidalgo A, Leperlier D, et al. One stage functional end-to-end stapled intestinal anastomosis and resection performed by nonexpert surgeons for the treatment of small intestinal obstruction in 30 dogs. *Vet Surg*. 2011;40(2):216–222. doi:10.1111/j.1532-950X.2010.00784.x
8. Duell JR, Thieman Mankin KM, Rochat MC, et al. Frequency of dehiscence in hand-sutured and stapled intestinal anastomoses in dogs. *Vet Surg.* 2016;45(1):100–103. doi:10.1111/vsu.12428

9. Snowdon KA, Smeak DD, Chiang S. Risk factors for dehiscence of stapled functional end-to-end intestinal anastomoses in dogs: 53 cases (2001–2012). *Vet Surg.* 2016;45(1):91–99. doi:10.1111/vsu.12413
10. Davis DJ, Demianiuk RM, Musser J, Podsiedlik M, Hauptman J. Influence of preoperative septic peritonitis and anastomotic technique on the dehiscence of enterectomy sites in dogs: a retrospective review of 210 anastomoses. *Vet Surg*. 2018;47(1):125–129. doi:10.1111/vsu.12704
11. DePompeo CM, Bond L, George YE, et al. Intra-abdominal complications following intestinal anastomoses by suture and staple techniques in dogs. *J Am Vet Med Assoc*. 2018;253(4):437–443. doi:10.2460/javma.253.4.437
12. Ellison GW, Case JB, Regier PJ. Intestinal surgery in small animals: historical foundations, current thinking, and future horizons. *Vet Surg.* 2019;48(7):1171–1180. doi:10.1111/vsu.13275. Published correction appears in Vet Surg. 2019;49(1):233. doi:10.1111/vsu.13376
13. Hayes G. Gastrointestinal foreign bodies in dogs and cats: a retrospective study of 208 cases. *J Small Anim Pract.* 2009;50(11):576–583. doi:10.1111/j.1748-5827.2009.00783.x
14. Ellison GW. Complications of gastrointestinal surgery in companion animals. *Vet Clin North Am Small Anim Pract*. 2011;41(5):915–934, vi. doi:10.1016/j.cvsm.2011.05.006
15. Gill SS, Buote NJ, Peterson NW, Bergman PJ. Factors associated with dehiscence and mortality rates following gastrointestinal surgery in dogs. *J Am Vet Med Assoc*. 2019;255(5):569–573. doi:10.2460/javma.255.5.569
16. Weisman DL, Smeak DD, Birchard SJ, Zweigart SL. Comparison of a continuous suture pattern with a simple interrupted pattern for enteric closure in dogs and cats: 83 cases (1991–1997). *J Am Vet Med Assoc*. 1999;214(10):1507–1510. doi:10.2460/javma.1999.214.10.1507
17. Lanz OI, Ellison GW, Bellah JR Jr, Weichman G, VanGilder J. Surgical treatment of septic peritonitis without abdominal drainage in 28 dogs. *J Am Anim Hosp Assoc*. 2001;37(1):87–92. doi:10.5326/15473317-37-1-87
18. Ellison GW. Wound healing in the gastrointestinal tract. *Semin Vet Med Surg Small Anim*. 1989;4(4):287–293.
19. Thompson SK, Chang EY, Jobe BA. Clinical review: healing in gastrointestinal anastomoses, part I. *Microsurgery*. 2006;26(3):131–136. doi:10.1002/micr.20197
20. Mullen KM, Regier PJ, Ellison GW, Londoño L. A review of normal intestinal healing, intestinal anastomosis, and the pathophysiology and treatment of intestinal dehiscence in foreign body obstructions in dogs. *Top Companion Anim Med.* 2020;41:100457. doi:10.1016/j.tcam.2020.100457
21. Jönsson K, Jiborn H, Zederfeldt B. Breaking strength of small intestinal anastomoses. *Am J Surg*. 1983;145(6):800–803. doi:10.1016/0002-9610(83)90144-7
22. Girard E, Messager M, Sauvanet A, et al. Anastomotic leakage after gastrointestinal surgery: diagnosis and management. *J Visc Surg.* 2014;151(6):441–450. doi:10.1016/j.jviscsurg.2014.10.004
23. Weinstein J, Beck K, Quinn M, Jessen C. Evaluation of the abdomen using ultrasound following a ventral midline celiotomy. *Vet Radiol Ultrasound*. 2005;46(4):337–339. doi:10.1111/j.1740-8261.2005.00063.x
24. Matthews AR, Penninck DG, Webster CRL. Postoperative ultrasonographic appearance of uncomplicated enterotomy or enterectomy sites in dogs. *Vet Radiol Ultrasound.* 2008;49(5):477–483. doi:10.1111/j.1740-8261.2008.00412.x
25. Mareschal A, Penninck D, Webster CRL. Ultrasonographic assessment of long-term enterectomy sites in dogs. *Vet Radiol Ultrasound.* 2010;51(6):652–655. doi:10.1111/j.1740-8261.2010.01714.x
26. Boysen SR, Tidwell AS, Penninck DG. Ultrasonographic findings in dogs and cats with gastrointestinal perforation. *Vet Radiol Ultrasound.* 2003;44(5):556–564. doi:10.1111/j.1740-8261.2003.tb00507.x
27. Costanzo G, Linta N, Auriemma E, Perfetti S, Del Magno S, Diana A. Ultrasonographic assessment of early leakage in intestinal sutures in dogs. *Front Vet Sci.* 2023;10:1094287. doi:10.3389/fvets.2023.1094287. Published correction appears in Front Vet Sci. 2023;10:1192801. doi:10.3389/fvets.2023.1192801
28. Penninck D, d'Anjou MA, eds. Atlas of Small Animal Ultrasonography. 2nd ed. Wiley/Blackwell; 2015:281–285.
29. Ragetly GR, Bennett RA, Ragetly CA. Septic peritonitis: treatment and prognosis. *Compend Contin Educ Vet.* 2011;33(10):E1–E5.
30. McLachlin AD, Denton DW. Omental protection of intestinal anastomoses. *Am J Surg.* 1973;125(1):134–140. doi:10.1016/0002-9610(73)90018-4
31. Hinton LE, McLoughlin MA, Johnson SE, Weisbrode SE. Spontaneous gastroduodenal perforation in 16 dogs and seven cats (1982–1999). *J Am Anim Hosp Assoc*. 2002;38(2):176–187. doi:10.5326/0380176
32. Wang AW, Cauvi DM, Hawisher D, et al. The contribution of the omentum to the outcome from sepsis: an experimental animal study. *Shock*. 2019;52(6):604–611. doi:10.1097/SHK.0000000000001311
33. Mullen KM, Regier PJ, Ellison GW, Londoño L. The pathophysiology of small intestinal foreign body obstruction and intraoperative assessment of tissue viability in dogs: a review. *Top Companion Anim Med.* 2020;40:100438. doi:10.1016/j.tcam.2020.100438
34. Soeters PB, Wolfe RR, Shenkin A. Hypoalbuminemia: pathogenesis and clinical significance. *JPEN J Parenter Enteral Nutr.* 2019;43(2):181–193. doi:10.1002/jpen.1451
35. Goldwasser P, Feldman J. Association of serum albumin and mortality risk. *J Clin Epidemiol.* 1997;50(6):693–703. doi:10.1016/S0895-4356(97)00015-2