


Ultrasonographic features and prevalence of presumed gastric wall edema in dogs with hypoalbuminemia

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Abstract

Background: Ultrasonographic features of gastric wall edema have not been reported in dogs with hypoalbuminemia.

Objectives: To describe the prevalence and ultrasonographic features of gastric wall thickening in dogs with hypoalbuminemia and analyze correlation with serum albumin concentrations.

Animals: Forty-two dogs with abdominal ultrasound and diagnosis of hypoalbuminemia (<2.3 g/dL).

Methods: Retrospective search in the medical records from 2018 to 2019 was performed. Ultrasound studies were reviewed and >5 mm were considered gastric wall thickening. The gastric wall changes such as thickness, layering appearance, echogenicity, echotexture, distribution of lesions, and presence of peritoneal effusion were recorded. Serial ultrasonographic examination and histopathological findings were recorded if available. Mean serum albumin concentration of dogs with and without gastric wall thickening was compared.

Results: Prevalence of gastric wall thickening in dogs with hypoalbuminemia was 21.4% (95% confidence intervals 7.4-35.4%). Mean gastric wall thickness was 10.0 ± 2.0 mm. Preserved mucosal layer and thickening of submucosal layer were observed in all 9 dogs. Five dogs had 3-layer appearance in thickened submucosal layer. Diffuse wall thickening was observed in 6 dogs. All 9 dogs had peritoneal effusion. Subsequent changes of gastric wall thickening were observed in 3 dogs (range 4-70 days). Gastric wall edema was confirmed histopathologically in 2 dogs via necropsy. There was no correlation between serum albumin concentration of the dogs and gastric wall thickness.

Conclusions and clinical importance: Findings indicated that gastric wall edema is a common finding in dogs with hypoalbuminemia. However, serum albumin concentrations did not correlate with the gastric wall thickness.

KEYWORDS

canine, gastric wall thickening, hypoalbuminemia, submucosal edema, ultrasonography

Abbreviation: GI, gastrointestinal.

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1 | INTRODUCTION

Hypoalbuminemia is a common disease in humans and animals secondary to malnutrition, protein-losing enteropathy/nephropathy, or hepatic disease.^{1,2} Pancreatic edema has been reported in dogs with hypoalbuminemia as 1 of its complications.³ Other types of edematous conditions are also reported in humans with hypoalbuminemia, including the edema of the subcutaneous tissue,⁴ gallbladder wall,⁵ and gastric wall.⁶ The cause of gastric wall edema in patients with hypoalbuminemia is mostly because of decreased oncotic pressure,^{7,8} as described in human patients with cirrhosis.⁹ Additionally, gastric wall thickening because of hypertrophic gastropathy has also been reported in human patients with hypoalbuminemia secondary to Menetrier's disease.¹⁰ In veterinary medicine, gastric and duodenal wall edema has been described in a dog with experimentally induced hypoalbuminemia¹¹ and gastroduodenal intussusception,¹² and in dogs with pancreatitis.¹³ Reported ultrasonographic features of gastric wall edema in dogs with pancreatitis were thickened submucosal layer with preservation of mucosal layer.¹³

The specific ultrasonographic features of gastric wall edema in those cases may warrant clinical decision of a follow-up ultrasonographic evaluation.

The authors have occasionally observed moderate to severe gastric wall thickening with a thickened submucosal layer in dogs with hypoalbuminemia. However, there is a lack of reported description or observation on gastric wall thickening secondary to hypoalbuminemia in dogs. The clinical importance of this observation is unknown.

The authors hypothesized that gastric wall thickening because of edema could be a common ultrasound finding in dogs with hypoalbuminemia and could be correlated with serum albumin concentrations. The aim of this retrospective study is to describe the prevalence and ultrasonographic features of presumed gastric wall edema in dogs with hypoalbuminemia and analyze whether gastric wall thickness correlates with serum albumin concentrations.

2 | MATERIALS AND METHODS

2.1 | Experimental design

This is a retrospective case series study.

2.2 | Case selection

The Purdue University Veterinary Teaching Hospital (PUVTH) Medical Record database from 1 April 2018 through 31 March 2019 was electronically searched to identify dogs that had both hypoalbuminemia (<2.3 g/dL) and abdominal ultrasound performed within 24 hours from the blood sample collection. All ultrasonographic studies were performed by board-certified veterinary radiologists and radiology residents with the same ultrasound machine (Aplio i800, Canon Medical Systems USA, Inc, Tustin, California). A linear array (5-18 MHz) or microconvex array (4-11 MHz)

transducer was used. Histopathological findings (when available) were recorded. Dogs with clinically and ultrasonographically diagnosed pancreatitis, gastric ulcer, or gastritis, or suboptimal image quality ultrasound image of the gastric wall have been excluded from the present study.

2.3 | Ultrasonographic findings

Ultrasonographic still images, real-time recording cine-loops, or both of the gastric wall in the form of digital files were reviewed by 2 board-certified radiologists (M. M. and H. G. H.) by consensus with an image viewing workstation (Asteris Keystone viewer, Asteris Inc, Stephentown, New York). The gastric wall thicker than 5 mm was considered gastric wall thickening.¹⁴

The following criteria of the ultrasonographic gastric wall changes were evaluated for dogs with gastric wall thickening¹⁴: (a) thickness (mm), (b) layering appearance (preserved or loss of the 5-layers appearance; layer(s) of gastric wall involved), (c) echogenicity of the abnormal layer (hypoechoic, intermediate hyperechoic, or hyperechoic), (d) echotexture of the abnormal layer (homogeneous or heterogeneous; if heterogeneous, with or without lacy appearance), (e) distribution of lesions (diffuse vs focal; if focal, specify anatomic location), and (f) presence of peritoneal effusion (yes or no).

Overall gastric wall thickness was measured from the echogenic mucosal surface to the outer hyperechoic serosal layer. The individual layer thickness was evaluated between the interfaces of the 2 adjacent layers. When there was a loss of the wall layering, it was further characterized into partial or complete. The echogenicity of the abnormal layers was considered hypoechoic (if equal or darker than normal mucosa), intermediate hyperechoic (echogenicity between the normal mucosa and submucosa), and hyperechoic (equal or brighter to the normal submucosa). The abnormal echotexture was further classified as homogeneous or heterogeneous. Lacy appearance of the abnormal gastric wall could be further classified as hypoechoic lacy (hyperechoic background with hypoechoic striations) and hyperechoic lacy (hypoechoic background with hyperechoic striations). The distribution of the abnormal gastric wall thickening such as generalized or focal was noted. If focal, further description of the distribution of lesions such as ventral, dorsal, greater curvature or lesser curvature of the gastric fundus, gastric body, or gastric pylorus was noted. Circumferential thickening was noted if diffuse circumferential wall thickening is observed in 1 of the still images or real-time recording cine-loops. Circumferential wall thickening was not evaluated if the dorsal wall is not able to be evaluated because of gastric contents or gas. The presence or absence of peritoneal effusion was recorded. Ultrasonographic still images, real-time recording cine-loops, or both still images and cine-loops of the gastric wall from serial follow-up ultrasound(s) were also reviewed by the same methods when available.

2.4 | Data analysis

The prevalence of gastric wall thickening in dogs with hypoalbuminemia was calculated by the following formula: Prevalence (%) = (number of dogs

with hypoalbuminemia and ultrasonographic gastric wall thickening $[A]/$ total number of dogs with hypoalbuminemia $[T] \times 100$. The binominal 95% confidence intervals (CIs) of the prevalence were calculated by the following formula: $95\% \text{ CIs} = [A/T \pm 1.96\sqrt{A/(T^2)}]$. The mean serum albumin concentrations of dogs with or without ultrasonographic gastric wall thickening were calculated. The individual serum albumin concentrations and gastric wall thicknesses of dogs were shown in a scatter-plot graph.

3 | RESULTS

Forty-four dogs had an abdominal ultrasound within 24 hours from blood sample collection with the diagnosis of hypoalbuminemia (<2.3 g/dL). Two dogs were excluded from the present study because of suboptimal ultrasound image quality of gastric wall in 1 dog and ultrasonographic evidence of gastric ulcer in the other case. After exclusion, 42 dogs were included in the present study. Twenty-seven dogs only had ultrasonographic still images of the stomach, and 15 dogs had both still images and real-time recording cine-loops of the stomach for review.

Gastric wall thickening with hypoalbuminemia was observed in 9 dogs. Thus, the prevalence of gastric wall thickening in dogs with hypoalbuminemia was 21.4% (95% CI 7.4-35.4%, 9/42 dogs).

Within the group of dogs (9 dogs) with ultrasonographic gastric wall thickening, ultrasonographic still images and real-time recording cine-loops of the stomach were available in 8 dogs and the other 1 dog had only ultrasonographic still images of the stomach.

The mean gastric wall thickness was 10.0 ± 2.0 ; 6.3-15.0 (mean \pm SD; range) mm. Normal 5-layer appearance was present in 5 dogs (Figure 1A) and partial loss of wall layering between the submucosal and the muscularis layer was observed in the other 4 dogs (Figure 1B). Well-defined preserved mucosal layer and thickening of the submucosal layer were observed in all 9 dogs.

The thickened submucosal layer was intermediate hyperechoic in 4 dogs (Figure 1A,B). In the remainder 5 dogs, the thickened submucosal layer was observed to have 3-layer appearance with additional thin inner and outer hyperechoic layers with the thick central intermediate hyperechoic to hypoechoic layer (Figure 1C). Except for additional layering, the remainder of the thickened submucosal layer was



FIGURE 1 Ultrasonographic appearance of the thickened gastric wall; ventral wall of the gastric body. A, Intermediate hyperechoic thickening of the submucosal layer with preservation of the wall layering. B, Intermediate hyperechoic thickening of the submucosal and the muscularis layers with loss of wall layering between the submucosal and the muscularis layer. Preservation of the mucosal layer is present. C, Intermediate hyperechoic thickening of the submucosal layer with an additional central hypoechoic area (between dotted lines). Preservation of the mucosal layer is present. Lu, lumen; Ms, muscularis layer; Mu, mucosal layer; S, submucosal layer

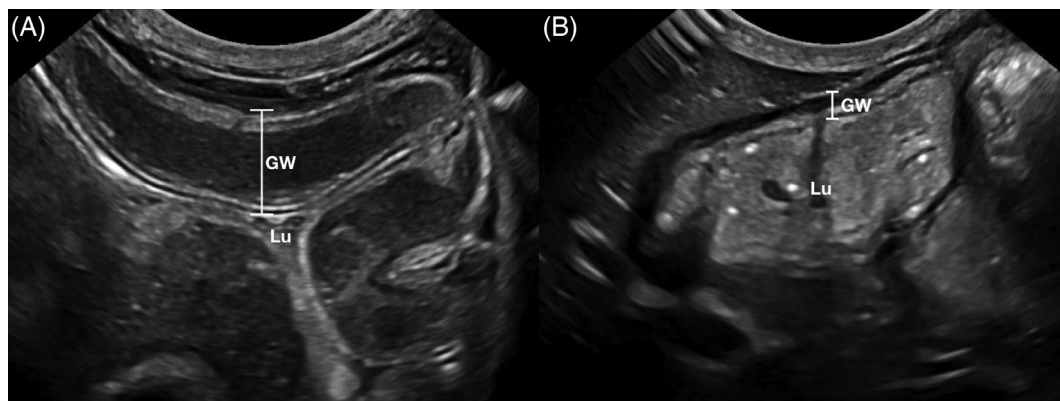


FIGURE 2 Serial ultrasonographic appearance of the gastric wall in a dog on Day 0 (A) and Day 4 (B) with resolution of gastric wall thickening. A, On Day 0, an intermediate hyperechoic thickening of the submucosal layer with additional hypoechoic central layer was present circumferentially. The gastric lumen is filled with echogenic fluid. B, Resolution of the gastric wall thickening was observed in Day 4. The gastric lumen is filled with heterogeneously hyperechoic material. GW, gastric wall; Lu, lumen

homogeneous in 7 dogs and slightly heterogeneous in 2 dogs. A hyperechoic lacy appearance was present within the thickened submucosal layer in 1 dog.

The distribution of lesions was only evaluated in 8 dogs because of a lack of real-time cine loop recording in 1 dog. Diffuse wall thickening was observed in 5 dogs and involving more than 75% of the gastric wall in 1 dog. Focal thickening of the ventral gastric wall and circumferential gastric pylorus were present in the remainder observed dogs. All 9 dogs had peritoneal effusion around the stomach.

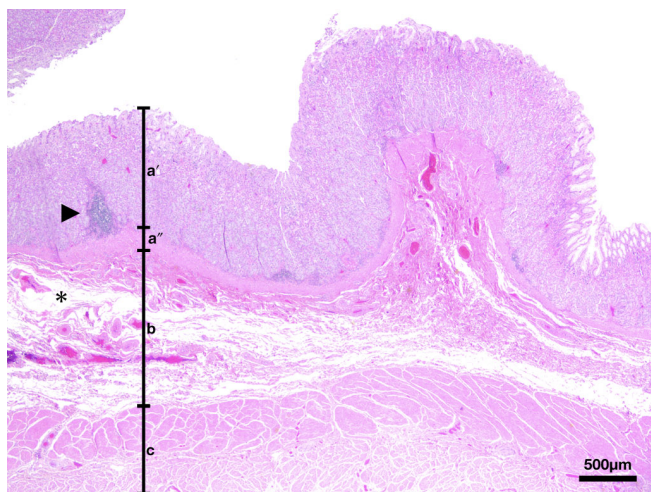


FIGURE 3 Photomicrograph of gastric submucosal edema in a dog with hypoalbuminemia. This image shows increased spacing with separation of collagen fibers caused by a nonstaining fluid within gastric submucosa (asterisk). Some vascular congestion and lymphatic dilation were also present in the submucosal layer. There was no evidence of inflammatory changes indicating gastritis or vasculitis. The layers of the stomach include: a', gastric mucosa; a'', muscularis mucosa; b, submucosa; c, muscularis. Included in the image are a few regions of gastric associated lymphoid tissue (black arrowhead). (Hematoxylin and eosin, x2)

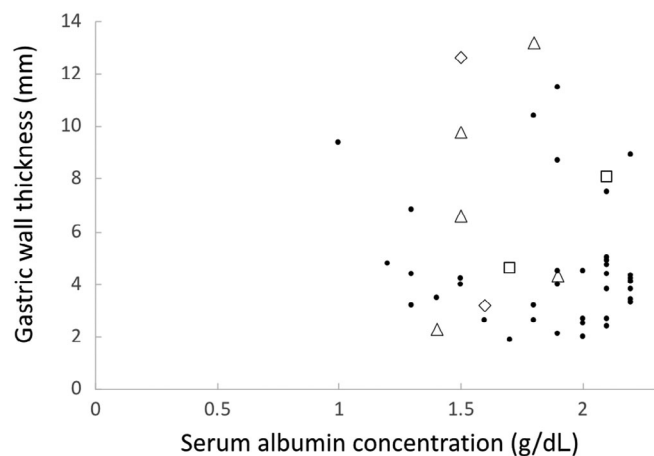


FIGURE 4 Serum albumin concentrations and gastric wall thickness of the dogs with hypoalbuminemia. The dogs with serial follow-up ultrasounds are shown with triangles (case 1), squares (case 2), and diamonds (case 3)

Serial follow-up ultrasounds were performed 6 times in 3 dogs. These dogs were all hypoalbuminemic during the period of the 6 ultrasound studies. Dog 1 had ultrasounds at Day 0 (initial presentation) and Day 4. Gastric wall edema was present only at Day 0 in Dog 1. Dog 2 had ultrasounds at Day 0 and 70. Gastric wall edema was present only on Day 70. Dog 3 had ultrasounds at Day 0, 34, 78, 116, and 236. Gastric wall edema was present only on Day 34, 116 (38 days after previous ultrasound study with normal gastric wall thickness), and 236. Altogether, subsequent resolution of gastric wall thickening was observed in 2 dogs (4 and 44 days each after previous ultrasound study with gastric wall thickening) (Figure 2A,B). Subsequent development of the gastric wall thickening was observed in 3 studies in 2 dogs (34, 38, and 70 days after previous ultrasound study with normal gastric wall thickness) during follow-up ultrasound.

Three dogs with gastric wall thickening underwent necropsy on the same day of the ultrasound studies. Submucosal edema with separation of collagen fibers, vascular congestion and lymphatic dilation was confirmed histologically in 2 dogs (Figure 3). There was no evidence of inflammatory changes indicating gastritis or vasculitis in any gastric wall samples (Figure 3). Tissue autolysis prevented the evaluation of the gastric wall in the remainder dog.

The mean serum albumin concentration of the hypoalbuminemic dogs with and without gastric wall thickening was 1.81 ± 0.37 and 1.89 ± 0.32 g/dL, respectively. The distribution of serum albumin concentrations and gastric wall thicknesses of individual dogs was shown in Figure 4.

4 | DISCUSSION

This study describes the prevalence and the ultrasonographic features of presumed gastric wall edema in dogs with hypoalbuminemia. The gastric wall thickening is a common (21.4%) ultrasonographic findings in the present study. The ultrasonographic gastric wall thickening resolved in the follow-up ultrasound as early as 4 days in 1 dog in the present study. This rapid resolution of wall thickening and the histological confirmation in 2 dogs might indicate that the ultrasonographic gastric wall thickening in the present study is because of edema.

The ultrasonographic features of gastric wall edema reported in dogs with acute pancreatitis were a thickened submucosal layer with a normal mucosal layer,¹³ and the same ultrasonographic features were present in all dogs (9/9 dogs) with gastric wall thickening in the present study. The ultrasonographic submucosal thickening can be caused by submucosal edema or hemorrhage. However, dogs with acute pancreatitis that had focal gastric wall thickening adjacent to the pancreas,¹³ whereas the gastric wall thickening is more diffuse in the population of our hypoalbuminemic dogs, involving more than 75% of the gastric wall in most of dogs (6/8 dogs).

Additional layers within the thickened gastric submucosal layer are commonly observed in the present study (5/9 dogs). This finding has not been reported in the previous study in dogs with acute pancreatitis. The additional layering is centrally hypoechoic (compared to additional inner and outer submucosal layer) layer with inner and outer

hyperechoic layers, and this additional layering may be explained by histological findings of separation of collagen fiber in the submucosal layer. The separation of collagen fiber secondary to ileal and colonic wall edema has been described in humans with Crohn's disease with severe intestinal wall edema and liquid accumulation in the submucosal layer.¹⁵ The etiology of separation of collagen fiber and ultrasonographic additional wall layering is not known, but the severity and the chronicity of gastric wall edema could have led to this additional layering and separation of the submucosal layer.

The underlying causes of GI wall edema include increased capillary hydrostatic pressure, reduction of intravascular oncotic pressure, increased capillary permeability, or obstruction of lymphatics.¹⁶ However, the GI wall edema secondary to hypoalbuminemia is usually considered because of the decrease in intravascular oncotic pressure.¹⁶ Peritoneal effusion is also observed in all dogs in the present study, most likely because of decreased oncotic pressure secondary to hypoalbuminemia. In the present study, the histological findings of vascular congestion and lymphatic dilation in the submucosal layer of the thickened gastric wall were present. Although vascular congestion and lymphatic dilation have been reported in GI wall edema, they were not cause specific. The serum albumin concentrations in dogs with and without ultrasonographic gastric wall thickening were widely scattering and overlapping each other, thus there is minimal correlation between the serum albumin concentrations and the presence of gastric wall thickening in the present study. One dog with serial follow-up ultrasound studies showed resolution of gastric wall thickening in the follow-up ultrasound study with persistent hypoalbuminemia. Therefore, the severity of hypoalbuminemia is not correlated with gastric wall thickening or severity of gastric wall edema. Thus, the gastric wall thickening observed in present study is unlikely to be solely attributable to hypoalbuminemia, but rather because of multitude of concurrent etiologies. Hypertrophic gastritis has been described as 1 of the possible causes of hypoalbuminemia in humans with Mentrrier's disease.¹⁰ The lacked of histological evidence of gastritis, the rapid resolution and subsequent development of gastric wall thickening in the follow-up ultrasound do not support gastritis as the cause of gastric wall edema.

In conclusion, the ultrasonographic gastric wall thickening is a common finding (21.4%) in dogs with hypoalbuminemia, and presumably because of gastric wall submucosal edema. Common ultrasonographic findings of gastric wall edema secondary to hypoalbuminemia in dogs include the preservation of the mucosal layer and diffuse thickening of the submucosal layer with or without additional central hypoechoic layer. However, the correlation between the gastric wall thickening and serum albumin concentration were not established.

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CONFLICT OF INTEREST DECLARATION

Authors declare no conflict of interest.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Authors declare no IACUC or other approval was needed.

HUMAN ETHICS APPROVAL DECLARATION

Authors declare human ethics approval was not needed for this study.

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