ULTRASONOGRAPHIC CHARACTERISTICS OF THE ABDOMINAL ESOPHAGUS AND CARDIA IN DOGS

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Differential diagnoses for regurgitation and vomiting in dogs include diseases of the gastroesophageal junction. The purpose of this cross-sectional study was to describe ultrasonographic characteristics of the abdominal esophagus and gastric cardia in normal dogs and dogs with clinical disease involving this region. A total of 126 dogs with no clinical signs of gastrointestinal disease and six dogs with clinical diseases involving the gastroesophageal junction were included. For seven euthanized dogs, ultrasonographic features were also compared with gross pathology and histopathology. Cardial and abdominal esophageal wall thicknesses were measured ultrasonographically for all normal dogs and effects of weight, sex, age, and stomach filling were tested. Five layers could be identified in normal esophageal and cardial walls. The inner esophageal layer was echogenic, corresponding to the cornified mucosa and glandular portion of the submucosa. The cardia was characterized by a thick muscularis, and a transitional zone between echogenic esophageal and hypoechoic gastric mucosal layers. Mean (±SD) cardial wall thicknesses for normal dogs were 7.6 mm (±1.6), 9.7 mm (±1.8), 10.8 mm (±1.6), 13.3 mm (±2.5) for dogs in the <10 kg, 10–19.9 kg, 20–29.9 kg and ≥30 kg weight groups, respectively. Mean (±SD) esophageal wall thicknesses were: 4.1 mm (±0.6), 5.1 mm (±1.3), 5.6 mm (±1), and 6.4 mm (±1.1) for the same weight groups, respectively. Measurements of wall thickness were significantly correlated with dog weight group. Ultrasonography assisted diagnosis in all six clinically affected dogs. Findings supported the use of transabdominal ultrasonography as a diagnostic test for dogs with suspected gastroesophageal disease.

Key words: anatomy, cardia, dog, esophagus, ultrasonography.

Introduction

Disorders of the gastroesophageal junction are among the causes for chronic weight loss, regurgitation, and vomiting in dogs. Diseases that can affect the cardial region in dogs include benign neoplasia (i.e., leiomyoma and polyps), malignant neoplasms (i.e., adenocarcinomas and leiomyosarcomas), inflammatory disease (i.e., gastroesophageal reflux and esophagitis), ulcers, herniation, and invagination.[1–10] Gastroesophageal reflux is the most common cause of esophagitis in animals and in people.[8,11] Esophageal or gastric leiomyomas are commonly found in the cardial area in dogs and cats.[9,10,12] They are usually asymptomatic but can occasionally lead to obstruction and regurgitation when large enough.[2,10] They are often intramural, smooth muscle tumors growing outward through the serosa as extraluminal masses, and they seldom project into the lumen.[1,12] Current standard diagnostic tests for evaluating the gastroesophageal region in dogs include survey radiography, contrast radiography,[3,13–15] computed tomography,[16,17] and endoscopy. Endoscopy is very helpful to assess esophagitis because one can visualize luminal or mucosal lesions such as hyperemia, ulcers, erosions, and mucosal hyperplasia.[18] When an esophageal or gastric leiomyoma is suspected, endoscopy may not be successful for obtaining diagnostic samples because those masses are typically covered with normal mucosa. Surgery is often required for the definitive diagnosis.[10] Then, transabdominal ultrasonography may allow visualization of transmural and exophytic masses of the gastroesophageal junction without the need of general anesthesia.

Transabdominal ultrasonography of the gastroesophageal junction has been previously described in normal

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and clinically affected human patients.[19–27] The cardial area has been imaged using the left lobe of the liver as an acoustic window.[22,24] Endosonography has also been widely used in people to assess the depth of neoplastic infiltration in the esophageal and gastric wall.[28,29] The normal and abnormal ultrasonographic and endosonographic appearances for the canine stomach, small intestine, and large intestine have been well-established.[1,3,30–35] The ultrasonographic appearance of the gastroesophageal junction has been previously described in a few veterinary reports.[2,31,36–38] Some authors have suggested that the region is difficult to visualize in dogs.[1]

The aim of our study was to describe the qualitative and quantitative transabdominal ultrasonographic characteristics of the gastric cardia (*gaster pars cardiaca*) and abdominal esophagus (*esophagus pars abdominalis*) in a large population of dogs free of signs of gastrointestinal disease. To illustrate clinical applications, the ultrasonographic characteristics of these structures in dogs with clinical disease involving the gastroesophageal region were described.

Materials and Methods

Dogs

This prospective study was performed from September 2011 to July 2013. Inclusion criteria for normal dogs were based on an owner questionnaire that was completed before each ultrasonographic examination: (1) there had to be no history of gastrointestinal signs or vomiting for at least 3 months prior to the examination, or since birth for the youngest animals (3-month-old); (2) the dogs had to be adequately dewormed; and (3) they had to be referred for reasons unrelated to gastrointestinal disease. Moreover, at the time of ultrasonographic examination, the abdominal lymph nodes (jejunal, gastric, or hepatic), liver and pancreas, had to have a normal ultrasonographic appearance, and the duodenal and jejunal wall thicknesses had to be within previously reported values.[39] As per our standard ultrasonography protocol, normal dogs were also expected to have been fasted prior to ultrasound examination. Six clinically affected dogs were also recruited for inclusion in the study. All dogs had been presented for suspected gastroesophageal disease, based on a history of regurgitation, chronic vomiting, and weight loss. Other abdominal structures in these animals were ultrasonographically within normal limits. The following body measurements for each included dog were recorded prior to, or following the ultrasonographic examination: body weight, maximum height of the thorax and body condition score. The maximum height of the thorax was measured, in centimeters, as the distance between the xiphoid process and the dorsal aspect of the spine, at a right angle relative to the vertebrae. Body condition was assessed using a 5-point system, based on body silhouette and palpation of adipose tissue (1 = extreme cachexia, 2 = underweight, 3 = optimal, 4 = overweight, 5 = extreme obesity).

Ultrasonography

The dogs were scanned without sedation (in order to standardize the protocol and to minimize potential bias), using a subcostal ventral abdominal approach or, occasionally, using a right lateral intercostal approach. A microconvex array transducer (9–5 MHz, MyLab60, Esaote, Genova, Italy; 11–8 MHz, Aplio400, Toshiba, Tochigi, Japan; 8–5 MHz, CX50, Philips Healthcare, Best, the Netherlands) or a convex array transducer (8–5 MHz, Aplio400, Toshiba, Tochigi, Japan) was used in resolution mode for all dogs. To image the cardia, the probe was placed in the sagittal plane in the cranial abdomen, and pressure was applied to obtain a longitudinal view of the aorta. The latter was followed cranially until the diaphragm became visible. The probe was then slightly displaced laterally to the left of the aorta. The esophagus and cardia were visualized ventrolateral to the aorta. As the abdominal esophagus runs obliquely from craniosagittal to a caudal-left parasagittal direction,[40,41] the probe was rotated 30–45° counterclockwise in order to align it with the cardia and the abdominal portion of the esophagus, to obtain a longitudinal plane. Transverse and longitudinal images were frozen and stored in a digital archive. Transverse images were acquired for anatomical description and comparison with gross pathology examinations. The degree of gastric distension was subjectively recorded.

Necropsy and Postmortem Ultrasonography

After ultrasonographic evaluation of the esophagus and cardia, seven dogs were humanely euthanized for reasons unrelated to digestive tract disorders. The stomach was removed including the caudal portion of the esophagus (from the thoracic aspect of the diaphragm) and the cranial portion of the duodenum (distal to its cranial curvature). An in vitro study was performed immediately after euthanasia in five of these seven dogs (three dogs between 0 and 9.9 kg, and two dogs of more than 30 kg). Then, they were removed and scanned in a water bath with the same transducer as that used in vivo prior to euthanasia. Moreover, in two of these five dogs, ultrasonographic examination was also performed after the abdominal cavity had been opened, with the stomach exposed but still in physiologic location and the probe directly in contact with the gastric serosal surface. The stomachs were then fixed in formalin. Longitudinal histologic sections of the caudal esophagus and cardia were obtained. No measurements were recorded from the histological sections because the thickness and gastric distension were altered by formalin.

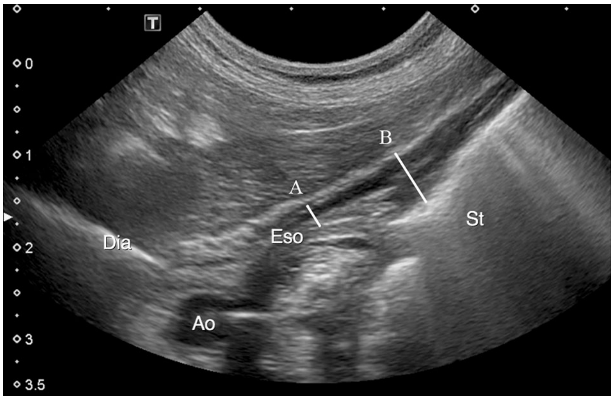

FIG. 1. Longitudinal image of a normal gastroesophageal junction in a dog. A = Ew: abdominal esophageal wall thickness; B = Cw: cardial wall thickness; Ao: aorta; Dia: diaphragm; Eso: esophagus; St: lumen of the stomach.

Image Analysis

Ultrasound images were retrieved and evaluated by two European College of Veterinary Diagnostic Imaging (ECVDI) diplomates (D.R. and L.C.) and one associate member of the ECVDI (E.C.). The quality of recorded images was randomly recorded by one of the observers (D.R.) several weeks after the initial examination; without knowledge of dog size, breed, weight, and other measurements. Measurements of wall thicknesses were made on frozen longitudinal images using electronic cursors in order to standardize the landmarks. Esophageal measurements were obtained from longitudinal plane images where the esophagus appeared tubular with its lumen collapsed. Measurements were made from the mucosal-lumen interface to the outer serosal surface. No measurements were made from transverse images. The ventral cardial wall thickness was assessed at the thickest portion of a visible bulge at the junction of the esophagus and cardia, also from the mucosal-lumen interface to the outer serosal surface (Fig. 1). For the seven euthanized dogs, the appearances of histologic sections and corresponding ultrasonographic images were compared. For the remaining dogs, ultrasound images were subjectively compared to histological findings and anatomy textbooks.[40–44]

Statistical Analysis

All statistical analyses were performed using commercially available statistics software (R package® 2.5.1).[45] Based on previous publications regarding ultrasonographic measurements of the duodenal and jejunal thickness, four weight groups were created (0–9.9 kg, 10–19.9 kg, 20–29.9 kg, and ≥30 kg).[39] Once measurements for each group were found to follow a normal distribution, the following calculations were made for each ultrasound measurement variable: mean, SD, 5% quantile, and 95% quantile. As variances were not homogeneous, the comparison of means was performed with a test for equal means in a One-Way layout and a Welch test.[46] Effects of gender and gastric distension were evaluated with a Student's *t* test. Correlations among body condition score, weight, maximum thoracic height and age, and ultrasound measurements were assessed with a Spearman's rank correlation test due to a nonellipsoid distribution of the data (the correlation coefficient and the 95% confidence interval were calculated).

Results

Normal Dogs

A total of 223 dogs met the clinical inclusion criteria. The gastroesophageal junction was well-visualized using ultrasonography in 188 (84.3%) of these dogs. The gastroesophageal junction could not be properly aligned for consistent longitudinal wall measurements in 62 (33%) of these dogs and they were therefore excluded from further analyses. Consequently, the final study population consisted of 126 dogs (115 purebred dogs and 11 mixed-breed dogs) were used for the anatomic study. The purebred population (53 breeds) included Golden retrievers ($n = 13$), Labrador retrievers ($n = 8$), Yorkshire terriers ($n = 8$), West Highland white terriers ($n = 5$), German shepherd dogs ($n = 4$), American Staffordshire terriers ($n = 4$), and Jack Russell terriers ($n = 4$). Other breeds were represented three times or less. There were 66 females (52%), 37 of which were neutered, and 60 males (48%), nine of which were neutered. Weights ranged from 2–72 kg and ages ranged from 3 months to 14.6 years. The mean body condition score was 3.5 (range: 2–5). The maximum height of the thorax ranged from 7 to 40 cm. The degree of gastric distension was subjectively categorized as empty stomach ($n = 101$), moderately full ($n = 14$), or markedly full ($n = 11$).

Histologic examination confirmed the normal appearance of the caudal esophagus and cardia in all seven of the euthanized dogs. In 112/126 dogs (89%), five ultrasonographic layers could be identified in the caudal esophagus (Fig. 2). This 5-layer appearance was visible in both longitudinal and transverse planes. The first ultrasonographic layer was thin and hyperechoic and corresponded to the outer serosa of the abdominal portion of the esophagus in histopathologic sections. The second layer appeared hypoechoic and corresponded with the muscularis. The third layer was a thin and hyperechoic interface and this corresponded with the submucosa. The fourth ultrasonographic layer of the esophageal wall appeared thick and echogenic and corresponded with the cornified mucosa and glandular portion of the submucosa. Finally, the fifth ultrasonographic layer was hyperechoic and represented the interface between the lumen and mucosa in histopathology sections.

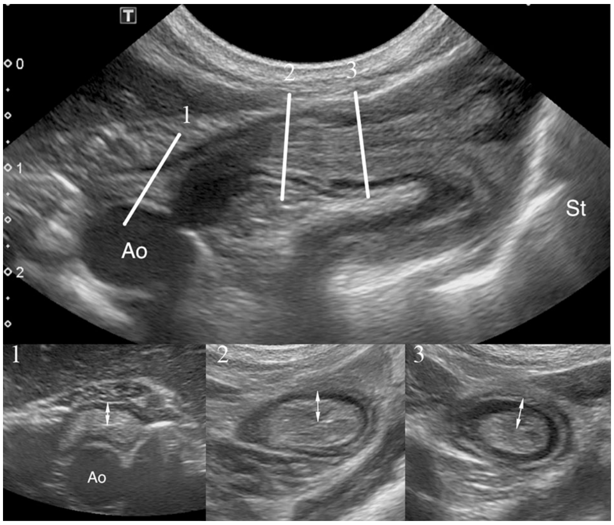

FIG. 2. Longitudinal image of the abdominal esophagus and associated transverse images at three different levels (Jack Russell Terrier, 8 kg, 16 cm of thoracic height). The more cranial portion of the abdominal esophagus was difficult to assess in a perpendicular plane (1) because of its deep location. Note the progressive increase in thickness of the muscular layer as it reaches the cardia, and the echogenicity of its inner layer (2 and 3). Ao: aorta; St: stomach.

The gastric cardia appeared as a thick parietal bulge with a smooth mucosal surface at the junction between the fundus (characterized by its folded mucosa) and the tubular esophagus (Fig. 1). Five alternating hypo and hyperechoic layers were seen ultrasonographically. Below the thin hyperechoic serosal interface, the hypoechoic muscularis layer thickened progressively from the caudal esophagus to the stomach (Fig. 2). The hyperechoic submucosal layer was continuous from the esophagus to the stomach. The mucosal layer appeared smooth, thick, hypoechoic, and devoid of rugal folds. In 71 dogs (56%), longitudinal ultrasound images of the cardial region revealed an abrupt transition between the echogenic inner layer of the esophagus and the thick, hypoechoic inner layer of the cardia. The water-bath study performed on stomachs removed postmortem from five dogs demonstrated the different ultrasonographic layers of the cardia with greater detail (Fig. 3).

There was a significant positive correlation between all ultrasonographic measurements and body weight, and between ultrasonographic measurements and the maximum thoracic height ($P < 0.05$) (Tables 1 and 2). Significant differences were observed between mean measurements for the four weight groups ($P < 0.05$). There was no significant correlation between any of the measurements and other variables of age, body condition score, or gastric distension ($P > 0.05$). There was no significant difference between ultrasound measurements for males and females ($P > 0.05$).

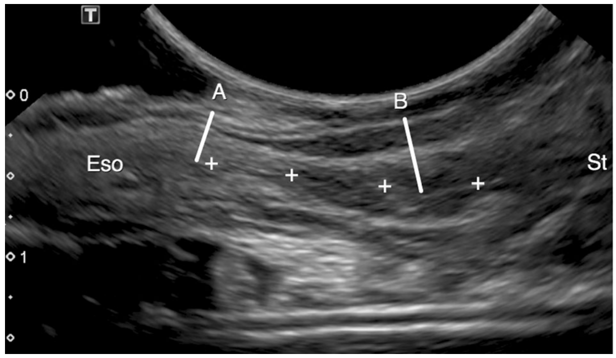

FIG. 3. Longitudinal image of a normal gastroesophageal junction in a water-bath. The lumen is outlined by calipers. The cardia (B) appeared as a thick parietal bulge with a smooth mucosal surface. The inner layer of the esophagus is echogenic, and the inner layer of the cardia is thicker and hypoechoic. (A) Abdominal esophageal wall thickness; (B) cardial wall thickness; Eso: esophagus; St: lumen of the stomach.

TABLE 1. Ultrasonographic Measurements of Esophageal and Cardial Wall Thickness in Relation to Weight

		Ew (mm)	Cw (mm)
0–9.9 kg	**Mean ± SD**	**4.1 ± 0.6**	**7.6 ± 1.6**
	5% Quantile	3.1	5.6
	95% Quantile	5	10.4
	Number of dogs	31	31
10–19.9 kg	**Mean ± SD**	**5.1 ± 1.3 a**	**9.7 ± 1.8**
	5% Quantile	3.5	7.3
	95% Quantile	7	11.7
	Number of dogs	21	21
20–29.9 kg	**Mean ± SD**	**5.6 ± 1 a**	**10.8 ± 1.6**
	5% Quantile	4.3	7.6
	95% Quantile	7.2	12.6
	Number of dogs	27	27
≥30 kg	**Mean ± SD**	**6.4 ± 1.1**	**13.3 ± 2.5**
	5% Quantile	4.4	10
	95% Quantile	8.2	18.1
	Number of dogs	47	47

Letter superscripts mark means that are not significantly different. In each column, other groups are significantly different from each other. Cw: cardial wall thickness; Ew: abdominal esophageal wall thickness.

TABLE 2. Correlation Between Body Condition Score, Weight, Maximum Thoracic Height, and Age for Esophageal Wall Thickness and Cardial Wall Thickness (Correlation Coefficient and 95% Confidence Interval) in 126 Clinically Healthy Dogs

	Ew	Cw
Weight	0.7	0.8
	[0.6; 0.77]	[0.73; 0.86]
Maximum thoracic height	0.69	0.77
	[0.57; 0.77]	[0.68; 0.83]
Body condition score	0.11	0.17
	[−0.06; 0.28]	[0; 0.34]
Age	−0.01	0.14
	[−0.19; 0.159]	[−0.03; 0.32]

For each parameter, first line is the correlation coefficient and the second line is the 95% confidence interval. Cw: cardial wall thickness; Ew: abdominal esophageal wall thickness.

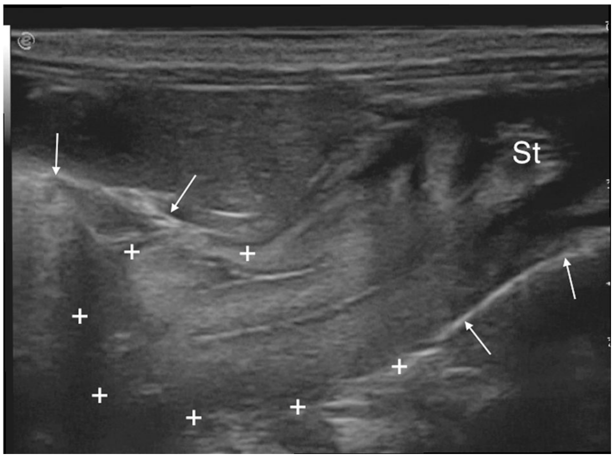

FIG. 4. Longitudinal image of the gastroesophageal junction in dog 1 with hiatal hernia. A portion of the gastric fundus (outlined by the calipers) extended cranial to the diaphragm, which is visible as a thin, smooth, hyperechoic interface (arrows) (cranial to the left, caudal to the right). The inner layer of the herniated portion had a folded appearance, and the herniated structure had a rounded shape. This was not consistent with esophagus.

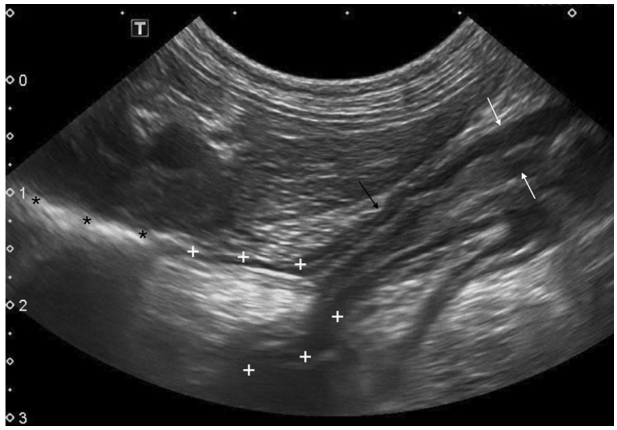

FIG. 5. Ultrasound image of the gastroesophageal junction in Dog 3. The cardia was in a normal location (white arrows). The diaphragm appeared as a bright linear hyperechoic interface (black ∗). The abdominal portion of the esophagus was collapsed (black arrow). The caudal thoracic portion of the esophagus was dilated with gas (outlined by the calipers). A functional megaesophagus was diagnosed.

Clinical Cases

Dog 1: A 5-month-old female Boxer presented with chronic regurgitation. Ultrasonography of the gastroesophageal junction revealed a portion of the gastric fundus moving back and forth through the esophageal hiatus of the diaphragm. The portion of the stomach that extended cranial to the diaphragm had a normal appearing wall layering that could not be misinterpreted as the abdominal esophagus because of the presence of an inner hypoechoic mucosa (Fig. 4). On dynamic examination, intraluminal gastric fluid was visualized moving from the stomach into the esophagus through the cardia. The confirmed final diagnosis was sliding hiatal hernia (type 1) associated with gastroesophageal reflux.

Dog 2: A 2-year-old French bulldog was presented for chronic regurgitation. On ultrasound, there was a tubular structure consistent with a small bowel loop near the diaphragm. The stomach and gastric cardia could not be clearly visualized in its normal position. A type 4 hiatal hernia was confirmed radiographically and at surgery.

Dog 3: A 4.5-year-old, 6 kg, Jack Russell Terrier, presented with chronic regurgitation and weight loss. Ultrasonographically, the stomach, cardia, and abdominal esophagus were within normal limits. Cranial to the esophageal hiatus, the visible thoracic portion of the esophagus was clearly dilated with gas (Fig. 5). Megaesophagus was confirmed with radiographs.

Dog 4: A 2-year-old, 10 kg, male French Bulldog presented with an acute onset of regurgitation. The stomach and cardia were within normal limits ultrasonographically. Immediately cranial to the esophageal hiatus, a sharply delineated, hyperechoic interface with distal acoustic shadowing was observed within the esophageal lumen (Fig. 6A). A caudal esophageal foreign body was confirmed with radiographs (Fig. 6B) and later at surgery.

Dog 5: A 7-year-old, 10 kg, male Cocker Spaniel was presented with regurgitation and weight loss of one-month duration. There was loss of the normal ultrasonographic layering in the abdominal esophagus and cardia. The wall was diffusely hypoechoic and markedly thickened (Fig. 7). Biopsies were obtained during endoscopy and revealed a carcinoma of the cardia that infiltrated the abdominal esophagus.

Dog 6: An 11.5-year-old, 8 kg, male Lhasa Apso was referred for chronic vomiting and weight loss. Ultrasonographic examination revealed a large, heterogeneous, hypoechoic, and exophytic mass at the level of the abdominal esophagus and cardia (Fig. 8). The histological diagnosis, based on surgical biopsies, was leiomyoma, leiomyosarcoma, or gastrointestinal stromal tumor. Immunohistochemistry could not be performed for further tumor type classification because of insufficient sample volume.

Discussion

Our study provides a detailed description of the ultrasonographic appearance of the canine gastroesophageal junction and thickness measurements of this region, based on a large number of dogs, spanning a wide range of ages, sizes, body condition scores, and breeds. The data representing the conformation of dogs, in particular the maximum thoracic height and the body condition score, allowed us to assess whether or not these parameters modified the examination of this junction. We found that the ultrasonographic examination of the cardia was feasible in the

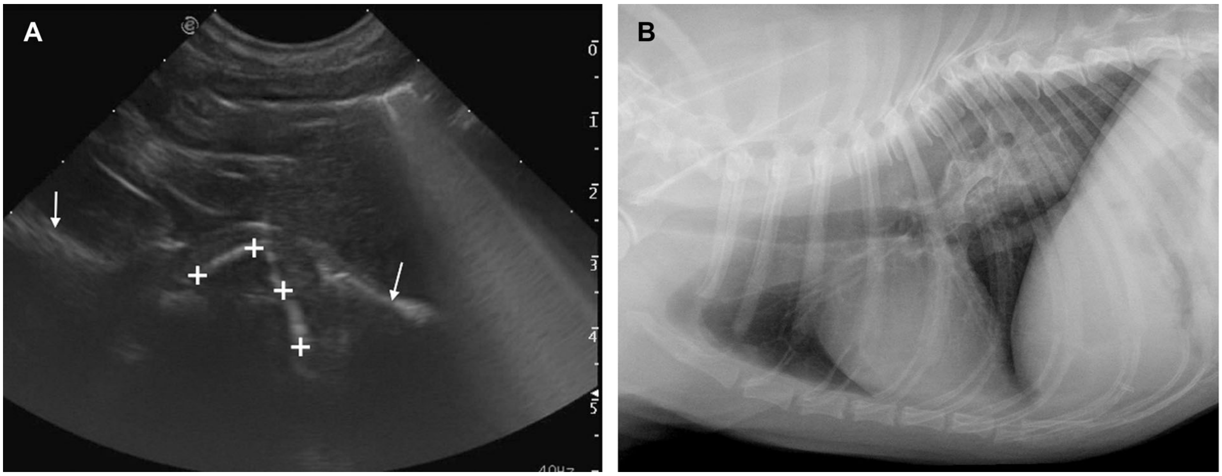

FIG. 6. Ultrasound and radiographic images of the gastroesophageal junction in Dog 4. (A) Cranial to the diaphragm (arrows), a sharply delineated hyperechoic interface with geometric margins (outlined by the calipers) and associated with distal acoustic shadowing is visible. (B) Radiographically, a sharply delineated mineral opacity is seen in the caudodorsal area of the lung field, and in the sagittal plane on the ventrodorsal view (not shown). It corresponded to a caudal esophageal foreign body that was confirmed at surgery.

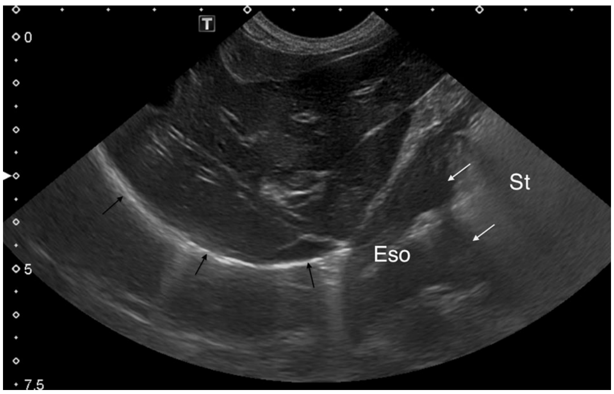

FIG. 7. Ultrasound image of the gastroesophageal junction in Dog 5. There is marked circumferential thickening of the wall of the caudal esophagus and cardia. It appears homogeneously hypoechoic, with complete loss of the normal layered structure (white arrows) (cranial to the left, caudal to the right). A carcinoma was diagnosed histologically. St: lumen of the stomach; Eso: esophagus; black arrows: diaphragm.

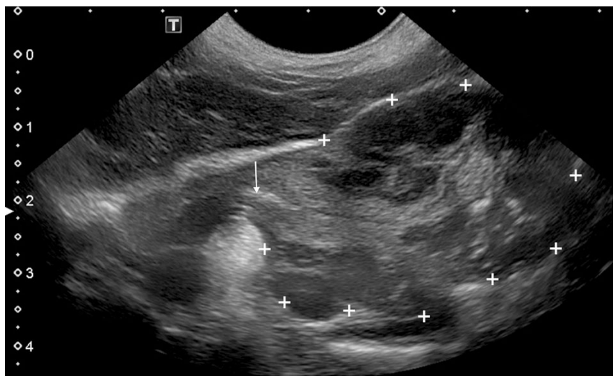

FIG. 8. Longitudinal ultrasound image of the gastroesophageal junction in dog 6 with a large (over 3 cm in thickness), multilobulated, heterogeneous, hypoechoic, and exophytic mass (outlined by the calipers) located in the wall of the cardia. The mass is continuous with the muscular layer of the cardia. There is loss of the normal ultrasonographic layering, and marked alteration of the contour of the wall. Histology identified a smooth muscle tumor. Arrow: lumen of the esophagus.

majority of dogs examined, even in several large breed or fat dogs. This finding differed from a previous report describing the gastric cardia to be difficult to assess ultrasonographically in dogs.[1] Significant pressure had to be applied with the probe on the skin to obtain an adequately aligned, longitudinal image of the cardia in the retroxiphoid space. Some dogs found this procedure rather uncomfortable. Microconvex or convex transducers were required to fit into this narrow window and achieve the correct angle. Furthermore, an experienced operator was needed to properly identify and position the cardia in order to standardize the measurements. Out of the 223 dogs that initially met inclusion criteria, we were unable to see the gastroesophageal junction in 28% of them and we excluded 62 of these dogs because of our inability to obtain longitudinal images for measuring both the cardia and esophagus. Consequently, only 126 dogs were used for the study. Sedation may have allowed us to assess the morphology of these structures in a larger number of dogs, especially in those that did not tolerate the pressure of the probe. We chose, however, not to use sedation in order to standardize the protocol and to avoid potential influence of sedation on thickness measurements. Likewise, no measurements were obtained from transverse images in order to standardize the protocol and avoid possible overestimation of measurements due to oblique slice planes. Moreover we found it easier to locate the focal bulging of the cardia on longitudinal images than on transverse ones.

We found that the histology and ultrasonographic appearances of the abdominal esophagus and cardia

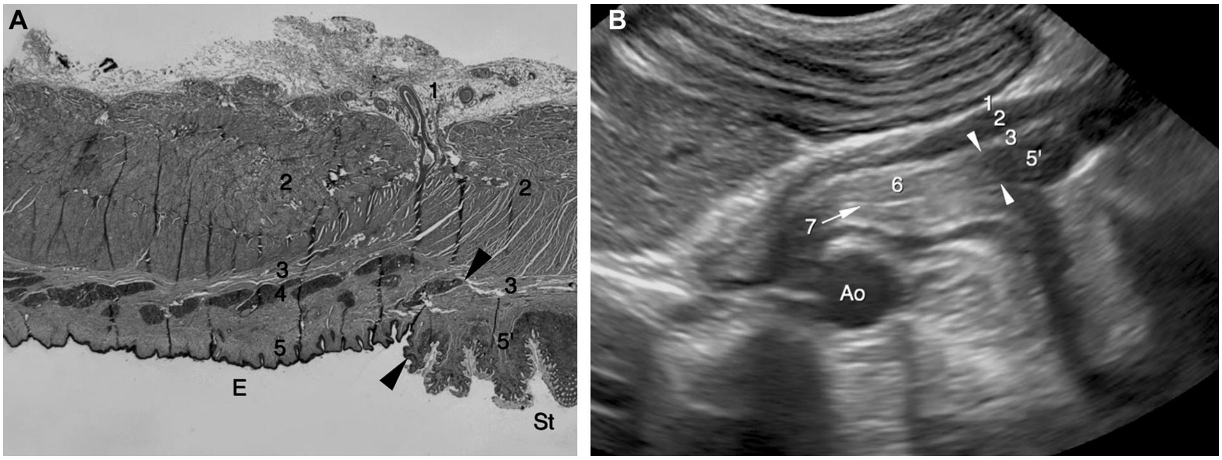

FIG. 9. Longitudinal histologic section of the esophagus and cardia in a normal dog (A) and associated measurements on ultrasonographic image (B) (esophagus (E) to the left and stomach (St) to the right). Note the gradually increasing thickness of the muscularis at the gastroesophageal junction, the sharp demarcation (arrowheads) between the esophageal and the gastric mucosa at the level of the cardia, and the latter's increased thickness. 1. Serosa; 2. Muscularis; 3. Areolar portion of the submucosa; 4. Glandular portion of the submucosa; 5. Mucosa of the esophagus (squamous epithelium + lamina propria of the mucosa); 5'. Mucosa of the cardia (glandular epithelium + lamina propria of the mucosa); 6. Inner echogenic layer of the esophagus (= 4 + 5); 7. Esophageal lumen; Ao: aorta.

corresponded well. In our study, we were able to visualize five ultrasonographic layers in the caudal esophagus in 89% of the dogs retained for the study. This differs from findings in a recent report describing the endosonographic appearance of the esophagus and in which five layers were seen in only 15.7% of healthy dogs. The authors in that study concluded that the thicker wall in the caudal part of the esophagus did not correlate with histologic findings in standard textbooks of veterinary histology.[35] In the current study, the outer serosa of the esophagus appeared hyperechoic. Histologically, this layer is composed of the tunica adventitia lined with peritoneum.[40,44] The muscularis layer of the esophagus is composed histologically of two oblique layers of striated muscle throughout its entire length that merge with smooth muscles at the cardial junction.[40] These two muscular layers could not be distinguished sonographically in the current study. The following thin hyperechoic layer represented the elastic areolar portion of the submucosa. This layer was continuous from esophagus to stomach. Contrary to the remainder of the digestive tract, which has a thick hypoechoic inner layer corresponding to the mucosa, the thick, innermost ultrasonographic layer of the abdominal esophagus was echogenic in the current study. This was unexpected and the corresponding histopathologic sections were examined more closely in an effort to explain this finding (Fig. 9). This echogenic inner layer appeared to be composed of three structural components: the glandular portion of the submucosa containing esophageal glands, the muscularis mucosae composed of a thin layer of smooth muscle, and the mucosa composed of a specifically stratified squamous nonkeratinized epithelium (Fig. 9).[6,40–44,47] The esophageal mucosa probably appeared echogenic in the current study because of its squamous nature.

The hyperechoic submucosal layer was continuous from esophagus to stomach and corresponded to submucosal connective tissue on post-mortem specimens. The cardia was also characterized by a hypoechoic mucosal layer as in the remainder of the stomach. There was an abrupt transition between the echogenic inner layer of the esophagus and the hypoechoic mucosal layer of the cardia. It was observed sonographically in 56% of our dogs, regardless of whether the ultrasound beam was perpendicular to the cardia or not. This in fact corresponded well with the abrupt histological transition between the thin, squamous mucosa, and glandular part of the submucosa on the esophageal side, and the thicker glandular mucosa of the cardia.[44] This transition, and the progressive thickening of the muscularis, were consistently visualized landmarks that allowed us to precisely identify the cardia. The cardia is a physiological rather than an anatomical sphincter. Nevertheless, it was characterized by a thick muscularis layer that progressively thickened histologically where the muscular fibers of the esophagus partially blended into the circular and oblique fibers of the stomach.[6,40,41,44] The inner circular muscular layer of the stomach thickened at this level to form the slight cardiac sphincter.

There was a significant positive correlation between all ultrasound measurements and body weight, and between all the measurements and the maximum thoracic height, suggesting that the higher the weight or height of the dog, the greater the thickness of the caudal esophagus and cardia, even though the standard deviation of the cardial wall thickness measurements was greater than that of the esophagus. Also, there was good agreement between the values we recorded for the caudal esophageal wall thickness (3–9 mm, the mean thickness being 5.5 mm) and mean measurements reported in an anatomical textbook of approximately 6 mm.[40] No correlation was found between the measurements and degree of gastric distension.

One limitation of our study was that systematic postmortem or histologic examination could not be performed in all dogs. To counterbalance the absence of systematic histologic confirmation that the stomach was normal, clinical inclusion criteria were strict and all components of the abdominal digestive tract and adnexal organs were thoroughly evaluated ultrasonographically. Only patients with intestinal thickness measurements within reference values were kept for the study. The measurements were carried out by three experienced radiologists, but a random review of all frozen images was also performed by only one radiologist in order to assess the validity of measurements recorded.

In this report, ultrasonographic abnormalities of the cardia in six dogs with clinical signs of regurgitation or vomiting and weight loss were included as examples to illustrate the potential clinical utility of ultrasonography for detecting gastroesophageal disorders and to illustrate how abnormal gastroesophageal junctions could appear different from normal ones. In two cases we found that megaesophagus and esophageal luminal foreign bodies could be detected on transabdominal ultrasonography. Authors acknowledge that the latter may not be the technique of choice, and radiography would likely allow a diagnosis of these conditions with greater reliability. Nevertheless, the associated clinical signs may initially wrongly suggest an abdominal disorder and the clinician may initially opt to perform abdominal ultrasonography. In addition, pathological conditions of the caudal esophagus and cardia such as hiatal herniation and gastroesophageal reflux were found to not only alter the wall thickness, echogenicity, and position of the gastroesophageal junction, but also alter the motility and diameter of the esophagus and cardia. These findings may be difficult to ascertain using endoscopy since general anesthesia would alter gut motility.

In conclusion, findings from this study indicated that the abdominal esophagus and gastric cardia could be assessed in the majority of dogs using ultrasound. Qualitative and quantitative descriptions from the current study may be useful as foundations for evaluating clinical or subclinical diseases of the gastroesophageal junction in future studies of dogs. Further studies are needed to assess the length of the abdominal esophagus from the diaphragm to the cardia, because variations have been shown to occur in specific breeds such as the Anatolian shepherd dog.[48] The obliquity between the abdominal esophagus and the gastric fundus may also warrant further documentation, as it is recognized as a major factor influencing the tonicity of the cardia.[6,47] Authors recommend that evaluation of the gastroesophageal junction should be part of routine ultrasonographic abdominal examinations in dogs, especially those with clinical signs of vomiting and/or regurgitation.

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Conflict of Interest

None of the authors of this article has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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