Endoscopic ultrasonographic evaluation of the esophagus in healthy dogs

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Objective—To characterize the ultrasonographic appearance of the canine esophagus.

Animals—14 healthy Beagles.

Procedures—Endoscopic ultrasonography (EUS) examinations were performed with a radial ultrasonographic gastrolescope in anesthetized dogs. Images were obtained at 3-cm intervals along the esophageal length to allow evaluation of the esophageal wall. Images were obtained with the probe in direct contact with the esophageal wall and with a water-filled balloon as a standoff.

Results—Images were obtained with (12 dogs) and without (10) the water-filled balloon. Median thickness of the esophageal wall was 2.19 mm (range, 1.03 to 5.62 mm) in the proximal third of the esophagus, 2.15 mm (range, 1.10 to 4.45 mm) in the middle third, and 2.84 mm (range, 1.35 to 5.92 mm) in the distal third. Wall thickness differed significantly between proximal and distal thirds. Results were similar when the water-filled balloon was used. Esophageal wall layers appeared as 5 alternating hyperechoic and hypoechoic bands that could not be consistently identified in all dogs. All layers could be identified in 26 of 198 (13%) images, 3 layers could be identified in 67 of 198 (34%) images, and 105 of 198 (53%) images had no layers. Visual identification of layers in images obtained with and without the balloon did not differ significantly.

Conclusions and Clinical Relevance—EUS appeared to be a useful technique for assessing esophageal wall integrity in dogs; however, complete evaluation of all layers could not be accomplished in all instances. Further studies with this technique in dogs are needed. (Am J Vet Res 2013;74:1005–1009)
to overcome interference attributable to gas artifacts or extreme obesity. Furthermore, EUS has been used to investigate the mediastinum and selected intrathoracic lesions in dogs. Histologically, the canine esophagus is composed of the tunica adventitia, tunica muscularis (outer longitudinal and inner circular layer), submucosal glands, and mucosa; the mucosa is composed of 3 layers. The histologic appearance of the esophagus of dogs is similar to that of the esophagus in humans. Use of EUS in humans has revealed a 5-layer structure with alternating hyperechoic and hypoechoic layers, which is similar to the appearance of the intestinal wall of dogs. The tunica adventitia is evident as a thin hyperechoic layer, the tunica muscularis is evident as a hypoechoic layer, the submucosa is hyperechoic, and the mucosa is hypoechoic. The innermost layer, the mucosal surface, has been described as a thin hyperechoic line.

To the authors’ knowledge, the ultrasonographic appearance of the canine esophageal wall has not been described. Therefore, the objective of the study reported here was to assess the use of EUS for the evaluation of the esophageal wall architecture in healthy dogs and to compare the EUS results with histologic results.

Materials and Methods

Animals—Fourteen healthy Beagles (8 sexually intact females and 6 sexually intact males) with a median body weight of 13.4 kg (range, 10.9 to 15.7 kg) and a median age of 2 years (range, 1 to 5 years) were included in the study. The dogs were considered healthy on the basis of their medical history and results of a physical examination, CBC, serum biochemical analysis, and urinalysis. The study was approved by the Committee for the Permission of Animal Experimentation, Canton of Zurich, Zurich, Switzerland.

Data collection—Food was withheld from all dogs for a minimum of 16 hours before the EUS examination. All dogs were anesthetized for the EUS examination. Sedation was provided by IM administration of acepromazine maleate (0.03 mg/kg) and buprenorphine (0.014 mg/kg). Anesthesia was induced by administration of propofol and maintained with isoflurane (1.1% to 1.3% in oxygen). Anesthetized dogs were positioned in left lateral recumbency, and the EUS examination was performed as described in another study. Images were obtained with an endoscopic processor, light source, and radial (360°) ultrasonographic gastrovideoscope (outer diameter, 13.8 mm; length, 1,250 mm) supported by an ultrasonographic unit. The ultrasonographic probe at the tip of the endoscope had a fundamental frequency of 5 to 10 MHz (Figure 1). Nonsterile balloons specially designed for the gastrovideoscope were attached to the transducer tip and could be filled with water and used as a standoff. Images were stored on the built-in hard disk of the ultrasonography machine and simultaneously transmitted to the image archiving and communication server of our hospital for further evaluation. The ultrasonographic gastrovideoscope was initially placed orally into the cardia of the stomach and then gradually retracted cranially toward the pharynx. The cardia was not evaluated. Fluid or gas in the esophagus was evacuated with the gastrovideoscope’s suction device to prevent interference with imaging. The first image was obtained as soon as the esophagus was visible, and images were obtained at 3-cm intervals throughout the length of the esophagus (the first image was obtained immediately cranial to the cardia, and the last image was obtained immediately caudal to the pharynx). The procedure was repeated, and a set of images was obtained with the balloon expanded with water to act as a standoff. Balloon distention resulted in a distance of approximately 2 mm between the probe tip and esophageal wall.

Evaluation of the wall thickness—Measurements of the thickness of the esophageal wall and evaluation of the layers of the esophageal wall were performed on images obtained at 3-cm intervals. Measurements were obtained with the scale on the ultrasonography machine. Wall thickness was measured 3 times/image, and the mean value was calculated. Because of the length of the esophagus, 9 esophageal images were generally obtained. Thus, the length of the esophagus was divided into thirds, each of which encompassed approximately 9 cm, for subsequent analysis.

Evaluation of the esophageal wall layers—The thickness, layers, symmetry, and echogenicity of the esophageal wall were assessed and compared with data obtained via esophageal EUS in humans and with results of histologic examination in dogs. For optimal visualization of the esophagus, the ultrasonographic probe should be perpendicular to the esophageal wall.
Attempts were made to optimize the image during the procedure by changing the angle of the transducer tip gradually until a reasonably symmetric image of the entire esophageal wall was visible in cross section with the subjectively smallest and most consistent wall thickness.

Statistical analysis—Wall thickness was analyzed via a 1-way ANOVA with Bonferroni correction. Values of $P < 0.05$ were considered significant. Statistical analysis was performed with statistical software.

**Results**

EUS images—Images were acquired only with the water-filled balloon for the first 4 Beagles. At that time, the decision was made to change the procedures to compare images obtained with and without the water-filled balloon. In addition, images were obtained only without the water-filled balloon for 2 dogs (the balloon did not fill correctly for one dog, and the insufflation canal was blocked and thus the balloon could not be filled during the examination for the other dog). Therefore, images were obtained with the water-filled balloon for 12 dogs and without the water-filled balloon for 10 dogs.

**Esophageal wall thickness**—Thickness of the esophageal wall increased from oral to aboral. For images obtained without the water-filled balloon, median wall thickness was 2.19 mm (range, 1.03 to 5.62 mm) in the proximal third, 2.15 mm (range, 1.10 to 4.45 mm) in the middle third, and 2.84 mm (range, 1.35 to 3.92 mm) in the distal third of the esophagus (Figure 2). For images obtained without the water-filled balloon, median wall thickness was 2.05 mm (range, 1.05 to 3.83 mm) in the proximal third, 2.20 mm (range, 1.09 to 3.88 mm) in the middle third, and 2.61 mm (range, 1.11 to 5.12 mm) in the distal third of the esophagus. There was a significant ($P < 0.001$) difference in thickness between the proximal and distal third of the esophagus. The thickness measured in images obtained with the water-filled balloon was smaller (but did not differ significantly [$P = 0.07$]) from the thickness measured in images obtained without the water-filled balloon.

**Esophageal wall layers**—The esophageal wall did not consistently appear as 5 alternating hyperechoic and hypoechoic bands. Generally, there were 3 variations when assessing the identification of layers.

![Figure 2](image1.png)

**Figure 2**—Box-and-whisker plots of the thickness of the esophageal wall determined from images obtained without (n = 12 dogs; A) and with (10; B) a water-filled balloon used as a standoff in healthy Beagles. Numbers on the x-axis represent the position of the probe tip in the esophagus at which images were obtained. The images were obtained at 3-cm intervals; 1 represents the image obtained from the most distal portion of the esophagus immediately adjacent to the gastric cardia, and 9 represents the last image obtained in the most proximal portion of the esophagus immediately caudal to the pharynx. Each box represents the 25th to 75th percentiles, the horizontal line within each box represents the median, and the whiskers represent the minimum and maximum.

![Figure 3](image2.png)

**Figure 3**—Ultrasonographic images of the esophagus of representative Beagles with no evidence of wall layers (A), 3 visible wall layers (B), and 5 visible wall layers (C). The outer and inner limits of the esophageal wall are indicated (arrows). In panels B and C, notice the hypoechoic region (asterisk) for the water-filled balloon that served as a standoff. AC = Carotid artery. T = Trachea.
Figure 3 for remainder of key.

See the esophagus portions of the esophagus and serosa in the abdominal portion of muscularis propria, and 5 = adventitia in the cervical and thoracic interface, 2 = mucosa and deep mucosa, 3 = submucosa, 4 = ageal wall are visible. The layers are as follows: 1 = mucosal wall thickness in 1 study.9 In that study,9 investigators filling of the balloon was associated with a decrease inpressive effects of an inflated balloon standoff; increased the esophageal wall thickness can be affected by com-

esophagus. In humans, accuracy of measurements ofcreased from the proximal to the distal aspects of the
wall.

Discussion

A main finding was that the wall thickness in-
creased in all examined individuals. The reason for this discrep-
ancy cannot be explained.

Use of the water-filled balloon did not influence our
ability to visually identify layers of the esophageal wall. It was believed that the water-filled balloon would in-
crease the distance between the transducer and esophageal wall to avoid problems with near-field imaging. For optimal visualization of the wall, the probe should be perpendicular to the esophagus. However, the angle between the probe and esophageal wall cannot be fully
avoided by evacuating the luminal gas in the esoph-
gus and by selecting images in which there were few or no reverberation artifacts. Because the thickness of the esophageal wall in dogs is comparable to that
in humans, we do not believe that spatial resolution achieved with the ultrasonographic equipment was the reason for our inability to observe the esophageal wall layers in all dogs, although the near-field properties of the equipment we used were not compared with those of the equipment used by the investigators in that hu-
man study.2

On the basis of the findings in the present study, a reduction in the number of esophageal wall layers cannot be considered a sign of disease. This is in contrast to imaging of the gastrointestinal tract in dogs, whereby the number of layers in the intestinal wall can be used
as a sign of disease in dogs with neoplastic or granulomatous changes.\(^{18}\)

Although the layers were not visible in all images, assessment of the ultrasonographic architecture of the esophageal wall is possible with EUS. In contrast to a study\(^9\) in humans, we could not consistently identify all layers of the esophageal wall in all dogs. The increase in wall thickness from oral to aboral has to be accounted for when considering esophageal disease. To our knowledge, the study reported here is the first to provide information about the normal EUS appearance of the esophagus in Beagles. This information may serve as a reference for further studies in dogs, including those with esophageal disease.

**References**


