

Use of a videofluoroscopic feeding evaluation to guide management of dogs with congenital idiopathic megaesophagus

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Abstract

Background: Evidence-based guidelines for determining dietary management in dogs with megaesophagus are lacking.

Objectives: This study looked to compare oesophageal clearance times (ECT) of liquid and two food consistencies using a contrast videofluoroscopy feeding evaluation, and to assess if recommendations made based on findings could improve regurgitation and quality of life in dogs with congenital megaesophagus.

Methods: Twenty-one dogs with congenital megaesophagus and nine healthy dogs received liquid, slurry, and meatball diets containing barium while in an upright position. Follow-up was performed to determine response to recommendations.

Results: Healthy dogs had significantly shorter median ECT for all consistencies ($p < 0.001$). In the megaesophagus group, ECT varied by consistency and individual. The number of dogs in the megaesophagus group with complete clearance was four (median ECT 10 min) for liquid, five (median ECT 5 min) for slurry, and two (median ECT 5 and 30 min, respectively) for meatballs. Partial clearance was seen in 11 dogs (median clearance 25%) with liquid, seven with slurry (median clearance 50%), and five with meatballs (median clearance 60%). Recommendations included altering current medications (13/21 dogs), diet consistency (6/21), time upright (12/21), water delivery (21/21), and adding activity (7/21). Regurgitation episodes/week decreased significantly from 5.5 to 2.5 ($p < 0.001$) at follow-up 3–5 weeks post-evaluation, with 95% of owners reporting improvement in quality of life. Seventy percent were alive 46–777 days after last recheck. Three dogs died from megaesophagus associated complications (median survival 461 days after diagnosis).

Conclusions: The findings of this study suggest that a videofluoroscopic feeding evaluation may help guide management of dogs with congenital megaesophagus.

KEYWORDS

dogs, gastroesophageal sphincter, megaesophagus, quality of life, regurgitation, videofluoroscopy

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1 | INTRODUCTION

Congenital idiopathic megaesophagus (ME) is a generalized dilation and hypomotility of the oesophagus of unknown aetiology that is found in puppies and often present from birth (Boudrieau & Rogers, 1985; Harvey et al., 1974; Washabau, 2003). Clinical signs may include regurgitation, poor body condition, aspiration pneumonia, and failure to thrive (Washabau, 2003). ME is associated with a high mortality rate and a grave prognosis. The main causes of death include aspiration pneumonia, malnutrition, and euthanasia with mean survival times reported to be 1–3 months (Boudrieau & Rogers, 1985; Harvey et al., 1974; McBrearty et al., 2011).

Treatment for the congenital form of ME consists of medical and dietary management. Evidence-based options for medical management are sparse, with a recent study suggesting that sildenafil may reduce regurgitation episodes in puppies with congenital ME (Quintavalla et al., 2017). Dietary recommendations include feeding a high calorie diet, providing elevated feedings, and feeding multiple smaller meals (Washabau, 2003). It is often advised that dogs be kept in an upright position following meals for up to 30 min. These recommendations are anecdotal with no evidence-based guidelines existing to support them and could be inadequate for many dogs (Haines et al., 2019). Additionally, no studies have shown that implementation of these recommendations results in improvements in clinical signs. Ultimately, feeding practices are often determined based on owner perception and via trial and error (Washabau, 2003). Formulation of evidence-based recommendations could optimize nutritional management of this patient group.

Videofluoroscopy (VF) is used for performing esophagrams and has been shown to be an effective method for assessing oesophageal clearance in normal dogs and dogs with ME (Bonadio et al., 2009; Haines et al., 2019; Imam et al., 2005; Pollard, 2012). A previous VF study found that dogs with ME showed high individual variation in ideal diet consistency and in the required time spent in an upright position post-feeding to maximize oesophageal clearance time (Haines et al., 2019). The study described a feeding evaluation technique that could be used to make recommendations on overall patient management. Used in this manner, VF has the potential to allow for individualized targeted recommendations for dogs with ME based on disease characteristics specific to that individual instead of general recommendations that may not be suitable for all dogs.

The aim of this study was to use the previously described VF feeding evaluation technique to compare the oesophageal clearance times (ECT) of different commonly recommended diet consistencies (liquid, slurry, and meatballs) in dogs with congenital idiopathic ME using contrast VF (Haines et al., 2019). In addition, the study further assessed if baseline oesophageal contrast VF could be used to guide dietary, pharmacologic, and general management decisions in dogs with ME. It was hypothesized that VF would allow for patient-specific recommendations that would result in improvements in clinical signs and quality of life. Finally, the study assessed survival data for the ME group evaluated in the study.

2 | MATERIALS AND METHODS

2.1 | Animals

This study was approved by the Institutional Animal Care and Use Committee. Dogs were enrolled prospectively from a population of otherwise healthy dogs previously diagnosed with idiopathic congenital ME. To be included in the study, the dog needed to be tolerant of sitting upright in a Bailey chair and eating willingly during the VF sessions. Dogs were considered to have an idiopathic congenital form of ME if they began showing clinical signs of ME and/or had radiographic evidence of ME prior to 6 months of age without history of an inciting cause or evidence of underlying disease on history, physical exam, CBC, biochemistry, urinalysis, and serum creatine kinase levels (Haines, 2019). Dogs with clinical signs of ME that did not have thoracic radiographs prior to 6 months of age had additional testing performed including basal cortisol/ACTH stimulation test, acetylcholine receptor antibody titres, and total T₄. The history collected information on current feeding strategies (diet consistency, time spent upright), regurgitation frequency, medications, and previous aspiration pneumonia.

At the time of enrolment, all dogs had thoracic radiographs (ventrodorsal, right and left lateral views) performed to confirm ME and to screen for aspiration pneumonia. If radiographic evidence of aspiration pneumonia was present, further inclusion in the study was postponed until resolution thereof. Owners were asked to rate their dogs' current quality of life as poor, fair, good, or excellent based on the owner's perceptions of the dog's ability and desire to perform normal daily activities, including exercise, play, and interaction with family members with decreases in quality of life potentially manifesting as frequent regurgitation episodes, pain, development of aspiration pneumonia, unwillingness to eat, hiding, lack of normal interaction, anxiety, or a depressed attitude.

A comparison group of client owned dogs were selected for inclusion if they were clinically healthy based on history, physical exam, CBC, biochemistry, and urinalysis. Comparison dogs were excluded if they had a history of regurgitation or dysphagia.

2.2 | Videofluoroscopic feeding evaluation

The VF feeding evaluation method used in this study was described in a previous study (Haines et al., 2019). Dogs were fasted for 12 h prior to imaging, and any medications were withheld on the day of imaging. Each dog was placed in a size appropriate Bailey chair on an adjustable hydraulic gurney, and a C-arm VF unit (Phillips Veradius Neo, Phillips Healthcare, Bothell, WA, USA) was placed around the dog and positioned to give a lateral view of the dog. The amount of diet fed for each consistency was calculated as 7% of the resting energy requirement for each dog. A commercial canned food diet (Purina EN, Nestle Purina PetCare, St. Louis, MO, USA) was used. The three consistencies used were 60% w/v liquid barium sulphate, a slurry of canned food and barium, and meatballs of canned food and barium. Slurry was made by

adding 250 ml water to 380 g food (1 can) to create a milkshake-like consistency. Dogs weighing <5 kg received 5 ml of liquid barium, 5–20 kg received 10 ml, and 21–40 kg received 15 ml. The total amount of canned food was divided equally to create five meatballs. All dogs received liquid first and then the order in which the dogs received the diets (slurry or meatball) was randomized using a coin toss. The VF was performed in two sessions with a 2-h break period between sessions. The first session consisted of liquid and one food consistency and the second session consisted of the alternative food consistency. VF was performed along the entire length of the oesophagus at baseline, for the first 20 s or until complete oesophageal clearance in comparison dogs, and then every 5 min for up to 15 min following liquid administration and 30 min after each diet type. Fluoroscopic evaluation was discontinued if all material cleared from the oesophagus or after 15 min for liquid and 30 min for slurry and meatballs, whichever came first. The ECT was defined as the time from ingestion of material to completion of movement of the material into the stomach (Haines et al., 2019). Partial clearance was determined based on visual estimation and was defined as 10%–90% clearance. Additional events that were noted during imaging included the presence of a visible oesophageal fluid line prior to initiation of imaging, gastroesophageal reflux, movement of barium into the intestines, and oesophageal contractions.

2.3 | Management recommendation guidelines

Based on the history, physical exam and VF findings, specific guidelines were made for each dog regarding medications, food consistency, time upright, post-meal activity, and administration of oral fluids.

Recommendations for medication administration were made using the following criteria: (1) If VF showed food retention and the dog was regurgitating more than once per week or if regurgitation frequency increased in the future, then omeprazole treatment (1 mg/kg twice daily) was recommended in case of secondary esophagitis (Bersenas et al., 2005; K. Tolbert et al., 2011). (2) If receiving famotidine and condition 1 criteria were met, then discontinuation and replacement of famotidine with omeprazole were advised (M. Tolbert et al., 2017; Williamson et al., 2010). (3) If VF showed incomplete clearance of all consistencies with retention above the gastroesophageal sphincter (GES), then sildenafil dosed at 1 mg/kg twice daily was recommended (Quintavalla et al., 2017). (4) If no gastroesophageal reflux was noted during the study and food retention occurred at the level of the GES, then discontinuation of metoclopramide or cisapride if being administered was advised.

Recommendations regarding food consistency, time upright, and post-meal activity were made as follows: (1) If VF showed faster or improved clearance of a consistency different from that being currently fed, then a change in diet consistency was recommended. (2) If none of the consistencies cleared significantly (>80%) and the dog was regurgitating food at home, then a trial of a diet consistency not included in the study (i.e., soaked kibble) could be attempted. (3) If ECT was shorter or longer than the time the dog was currently spending upright after

meals, then a change to a more rapidly clearing food consistency or change in the time spent upright could be made as appropriate based on VF findings. (4) If food was still present in the oesophagus after the first imaging session but was found to have moved into the stomach after the break period, then instituting activity (unrestricted activity or a walk) following meals was advised.

Criteria and associated recommendations regarding oral fluid administration were also provided. (1) If >25% of the thoracic oesophagus contained fluid (as indicated by a fluid line) or the dog showed no passage of liquid barium after 15 min, the dog should not have free access to water. (2) If slurry was seen to pass on VF, then it was advised to utilize water thickeners or increase the fluid content of the slurry diet. (3) If meatballs were seen to pass on VF, then gelatin blocks were advised to be used as water replacers. (4) If ingestion of food resulted in clearance of retained liquid on VF, then offering water immediately prior to meals was recommended.

2.4 | Follow-up

Follow-up communication was performed to assess compliance and response to management changes following the study visit. Owners completed a questionnaire reporting frequency of regurgitation, episodes of aspiration pneumonia diagnosed by a veterinarian; what recommended management changes had been made; and changes in the dog's quality of life. Clinical signs reported by the owner that could be consistent with aspiration pneumonia were not included in the analysis without confirmation by a veterinarian, as some signs such as coughing may occur due to other causes in dogs with ME. All owners were asked whether they felt their dog's quality of life had changed since instituting the recommended changes and to rate it as much worse, somewhat worse, no change, somewhat better, or much better. Survival time was recorded from the time of diagnosis.

2.5 | Statistical and data analysis

Data analysis was performed using statistical software (GraphPad Prism 7.00 for Windows, GraphPad Software, San Diego, CA and IBM SPSS® Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp). Gaussian distribution was assessed using Shapiro–Wilk test for normality. Diet consistency within the ME group was compared using Friedman's test. An omnibus analysis of variance (ANOVA) with $p < 0.05$ was performed for ECT with a follow-up Welch's t-test for ECT between the ME and healthy comparison groups. Wilcoxon matched-pairs signed rank test was used to compare number of regurgitations before and after intervention. A proportional hazards regression was done for the ME group with a p -value set at 0.05. A p -value of < 0.05 was considered significant.

Survival data were assessed using a Kaplan–Meier survival analysis. Dogs that were alive at the end of the study period and dogs that died for reasons other than ME or a complication thereof were censored at the date of last follow-up or death.

3 | RESULTS

3.1 | Population demographics

Twenty-one dogs with idiopathic congenital ME were included. The median (range) age for the group was 0.4 years (0.2–8 years) and median (range) weight was 13.6 kg (2–30.2 kg). Represented breeds included Labradors ($n = 4$), German shepherd dogs ($n = 3$), great Danes ($n = 2$), and mixed breeds ($n = 6$) with 1 each of golden retriever, miniature dachshund, border collie, Lakeland terrier, Welsh terrier, and miniature schnauzer. There were a total of seven intact females, four spayed females, five intact males, and five neutered males. The median time (range) from initial diagnosis with congenital megaesophagus to study enrolment was 73 days (20–2716 days). The study date had to be postponed in one dog due to the presence of aspiration pneumonia found during initial screening.

Nine client owned dogs were recruited for the healthy comparison group. The median (range) age for the comparison group was 4 years (range 1–12 years) and median (range) weight was 16 kg (5.4–30.3 kg). There were a total of seven spayed females and two neutered males. Represented breeds included two golden retrievers, three mixed breed dogs, and one each of Labrador, miniature poodle, Australian cattle dog, and Pembroke Welsh corgi.

3.2 | Videofluoroscopy

The ECT for complete clearance was significantly different between dogs with congenital ME and the healthy comparison population for meatball ($p < 0.001$), liquid ($p < 0.001$), and slurry ($p < 0.001$) groups (Table 1). No dogs in the comparison group displayed any retention of ingesta within the oesophagus. The clearance data for the ME group is shown in Table 2.

Four of the 21 dogs had complete clearance of liquid. In the remaining 17/21 dogs with only partial clearance, the liquid was retained at the level of the gastroesophageal sphincter (GES). Following the subsequent feeding of either slurry or meatballs, the retained liquid had moved into the stomach within 5 min in 14/17 dogs, and within 15 min in 2/17 dogs.

Five of 21 dogs had complete clearance of slurry. In the remaining 16/21 dogs with no or partial clearance, the slurry was retained at the level of the GES in 14 dogs and reached the GES within 5 min of ingestion. In two dogs, slurry was retained within the distal thoracic oesophagus and did not reach the GES.

Complete clearance of meatballs occurred in 2/21 dogs. In the remaining 19/21 dogs with no or partial clearance, the meatballs were retained at the level of the GES in 14 dogs, reaching the GES within 5 min in 13 dogs and within 10 min in one dog. In 5/21 dogs, meatballs were retained within the thoracic oesophagus and did not reach the GES during evaluation. Figure 1 demonstrates examples of retained material at the GES.

Gastroesophageal reflux was not noted in any of the dogs, and all dogs had movement of contrast material into the intestines by the end of the final VF imaging session. In 8/21 (38%) of the dogs, oesophageal contractions were noted during the imaging period that did not correspond with opening of the GES. None of the healthy dogs were noted to have gastroesophageal reflux and all had normal oesophageal contractions with coordinated GES opening. There were no incidences of aspiration seen during imaging and no other complications occurred in this group after imaging.

3.3 | Recommendations

At the time of enrolment, dogs in the ME group were receiving a variety of diet consistencies with some receiving multiple consistencies including slurry ($n = 4$), gruel ($n = 5$), meatballs ($n = 1$), canned food ($n = 4$), soaked kibble ($n = 10$), and dry kibble ($n = 2$). Seventeen of 21 (81%) dogs had access to free choice water at home, 2/21 (9.5%) received water only as part of their food, and one dog only received water as gelatin cubes and as part of the food. The median amount of time dogs were kept upright following meals at home was 20 min (range 0–40). Five dogs were receiving one or more medications including metoclopramide ($n = 2$), cisapride ($n = 1$), famotidine ($n = 3$), omeprazole ($n = 2$), and maropitant ($n = 1$). Recommendations made are summarized in Table 3. Recommended medication alterations included stopping prokinetic medications in two dogs, stopping famotidine in three dogs, starting omeprazole in 11 dogs, and starting sildenafil in three dogs.

3.4 | Follow-up and survival

Response to management changes made based on post-VF recommendations was evaluated in all dogs between 3–8 weeks. Owners were asked to report if they had made the advised changes to their dog's management plan. Owners showed variable rates of compliance with advised recommendations (Table 3). Eight owners made one recommended change, seven made two changes, and five made three

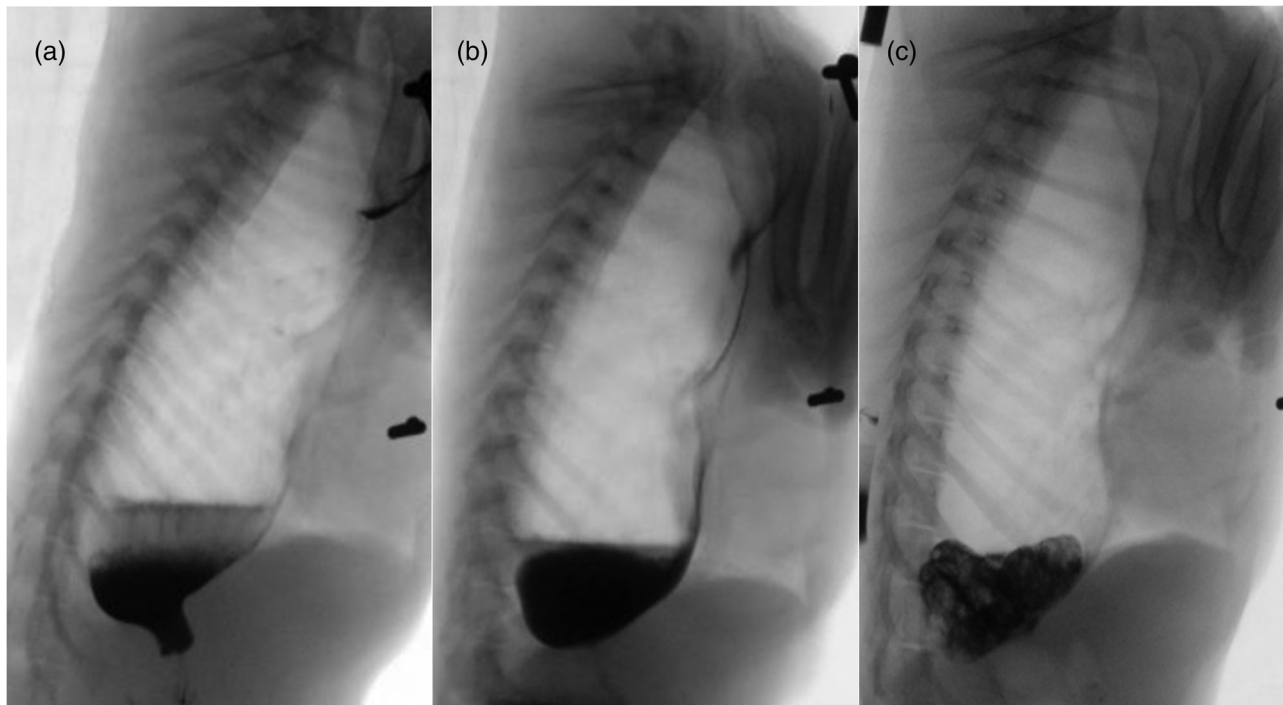
TABLE 1 Oesophageal characteristics and oesophageal clearance time (ECT) of healthy comparison and megaesophagus (ME) groups

Characteristics	Healthy group ($n = 9$)	ME group ($n = 21$)
Presence of fluid line	Zero dogs	Eight dogs (38%)
Liquid: Median (range) ECT	6 s (2.8–20)	>15 min
Slurry: Median (range) ECT	5 s (2.1–8.0)	>30 min
Meatball: Median (range) ECT	4 s (3.1–6.1)	>30 min

TABLE 2 Oesophageal clearance time (ECT) of liquid, slurry, and meatballs in the megaesophagus (ME) group ($n = 21$)

Consistency	Complete clearance		Partial clearance			No clearance
	No. of dogs	Median (range) ECT	No. of dogs	Median time to maximum clearance	Median (range) clearance percentage	No. of dogs
Liquid	4 (19%)	10 min (5–15)	11 (52%)	5 min	50% (10%–80%)	6 (29%)
Slurry	5 (24%)	5 min (1–30)	7 (33%)	5 min	50% (30%–90%)	9 (43%)
Meatball	2 (10%)	5 min; 30 min ^a	5 (24%)	5 min	60% (20%–60%)	14 (67%)

^aOnly two dogs had complete clearance following ingestion of meatballs, so ECT for each dog is listed instead of median (range).

**FIGURE 1** Videofluoroscopic images of a dog with congenital megaesophagus showing oesophageal retention of liquid barium (a), slurry (b), and meatballs (c) at the level of the lower oesophageal sphincter**TABLE 3** Recommendations made and instigation of recommendations

Recommendation made	No. of dogs ($n = 21$)	No. of dogs in which recommendations were followed
Change in diet consistency	6 (29%)	4/6
Change in manner of liquid administration	21 (100%)	15/21
Time kept upright following meals	12 (57%)	8/12
	Reduction ($n = 7$)	
	Increase ($n = 5$)	
Addition of post meal activity	7 (33%) ^a	4/7
Add or alter medication	13 (62%)	6/13

^aAddition of post-meal activity could not be assessed in four dogs due to complete clearance of ingesta during the first feeding session.

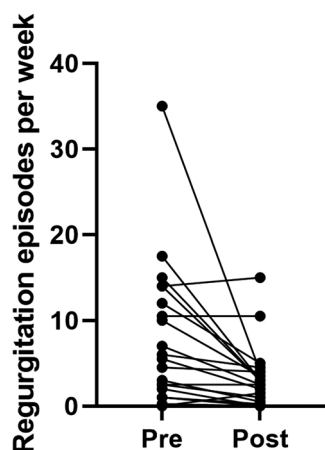


FIGURE 2 Regurgitation episodes by individual dog with megaesophagus before and after intervention

changes. The number of regurgitation episodes per week, as reported by owners, decreased significantly from a median of 5.5–2.5 regurgitations per week following the imaging procedure ($p < 0.001$) (Figure 2). Regurgitation episodes improved in 2/3 dogs in which sildenafil was added and in 3/4 dogs in which omeprazole was added; however, this was not the sole change made in any of these dogs. Alterations in water delivery was associated with reduced regurgitation episodes in 13/15 dogs and was the only change made in five dogs. Increasing time spent upright after meals was associated with reduced regurgitation episodes in 4/4 dogs but was not the sole change made in any dog. Addition of activity was only made in 1/4 dogs and while regurgitation episodes improved, it was not the only change made in that dog's management. When questioned, 16/21 (76%) of clients perceived their dog's quality of life to be much better, 4/21 (19%) to be somewhat better, and 1/21 (5%) saw no change in quality of life after the imaging was performed. The owner who reported no change in quality of life elected not to make any changes in management based on study recommendations.

A final follow-up was performed at the time of writing to determine survival or resolution of ME. Three dogs (14%) from the ME group had died or were euthanized due to ME associated complications. Of these, two were euthanized due to aspiration pneumonia and one due to a gastroesophageal intussusception. These three dogs survived a median of 461 days (range: 193–596 days) from time of diagnosis. Thirteen dogs were known to still be alive and three were lost to follow up. One dog was euthanized due to an intestinal foreign body obstruction 207 days after ME diagnosis and one was euthanized due to orthopaedic disease 2991 days after diagnosis. One dog had resolution of ME 272 days following diagnosis, confirmed radiographically at 11.7 months of age.

Based on a Kaplan–Meier survival analysis, the overall median survival time for the study group could not be statistically assessed because the dogs overall did well and the survival proportion never dropped below 0.703 (standard error: 0.136). A proportional hazards regression for the ME group showed that age was not a significant predictor in outcome (death) ($p = 0.328$). Seventy percent of the dogs

were still alive at the last follow-up ranging from 46–777 days after diagnosis.

4 | DISCUSSION

The results of this study suggest that the use of a contrast VF feeding evaluation to guide management recommendations in individual subjects may lead to significant reductions in regurgitation episodes and improvements in perceived quality of life. The imaging further found that liquid and food were most often retained due to failure of GES relaxation and dyssynchrony of oesophageal contractions and GES opening. Overall survival times in this study group exceeded previously described survival times in dogs with ME; however, the impact of the VF feeding evaluation on survival times was not an aim of this study (Boudrieau & Rogers, 1985; Harvey et al., 1974; McBrearty et al., 2011).

When further comparing different food consistencies, it was noted that feeding meatballs resulted in the poorest clearance overall. The slurry consistency was somewhat better with a lower rate of no clearance and higher partial and complete clearance. Most, but not all, dogs had full or partial clearance of slurry and meatballs well before the 30 min (< 20 min). Based on these findings, without the benefit of VF guidance, a slurry consistency is a reasonable first choice diet with dogs being kept upright for 20–30 min following food consumption. The effect of body position on ECT was not assessed and additional research is needed to guide recommendations about ideal body position and duration of positioning in dogs with ME.

Only four of the dogs had complete clearance of liquid from the oesophagus suggesting a liquid intolerance in the ME group overall. This is further supported by eight dogs having an existing fluid line in the oesophagus suggesting pre-existing retained liquid or previous gastroesophageal reflux. The liquid barium still reached the stomach or collected in the oesophagus at the level of the GES in all dogs, meaning that it was able to move past the pre-existing liquid. The composition of the pre-existing liquid was not determined in this study and could represent water, saliva, other ingesta, or reflux. The higher viscosity found in 60 v/w barium solution compared to water may also have contributed to its movement to the GES. Future studies may benefit from more dilute barium or less viscous contrast agents (i.e., diluted iohexol) (Gerk & Mrowietz, 2013; Stokely et al., 2014).

It was noted in the majority of dogs that ingesta moved rapidly to the GES via passive gravitational effects when dogs were placed in the vertical position. Retention of the ingesta occurred most often at the level of the GES, with the GES showing a failure to open appropriately, but often showing delayed opening up to 30 min later. This varied in some individuals based on the consistency of material consumed. This supports the idea that the GES retains the ability to function normally in many dogs with ME but that the mechanisms triggering its relaxation may be altered. The GES opens as a result of sensory stimulation in the pharynx during swallowing and oesophageal distension causing increases in luminal bolus pressure (Boeckxstaens, 2005; Hershovici et al., 2011). Dogs with ME may have alterations in the afferent sensory

pathways preventing GES relaxation or disrupting normal coordination (Holland et al., 1996, 1994, 2002). Eight dogs in this study were noted to have some degree of oesophageal contractions that did not coordinate with GES opening. The findings of our study further support the concept that the use of therapies to relax the GES, such as sildenafil, could be beneficial in the management of dogs with idiopathic congenital ME (Quintavalla et al., 2017). At the time this study was designed, no veterinary publications were available supporting the use of sildenafil for dogs with ME, and one only became available when this study was nearing completion. For this reason, sildenafil was only recommended in three of the dogs who had failure to clear any diet consistency sufficiently. Sildenafil treatment may have been beneficial in other dogs with frequent regurgitation and failure to clear any diet consistency.

Megaoesophagus is seen to develop in people due to achalasia, a primary oesophageal motor disorder causing reduced or absent oesophageal peristalsis, GES hypertonicity, and failure of the GES to open in response to swallowing (Patel et al., 2015). Only one case report of primary achalasia diagnosed via manometry has been reported in the veterinary literature (Kempf, Beckmann, et al., 2014). Dogs with ME also appear to have dyssynchrony between swallowing, and GES relaxation though hypertonicity is not typically documented. A recent study, published after this study's completion, identified an achalasia-like syndrome in some dogs with ME (Grobman, Schachtel, et al., 2019). This syndrome was defined as failure of the GES to relax in response to a pharyngeal swallow as demonstrated on standing VF. For this study, GES response to swallow was not evaluated but instead the ability of the oesophagus to clear material regardless of reflex response to a swallow was assessed. Many of the dogs in this study were still able to partially or fully clear ingesta from the oesophagus independent of the initial swallow and the clearance of the oesophagus appeared to be more dependent on ingesta consistency. This finding is in contrast to the previous study and suggests that GES hypertonicity and therefore primary achalasia is not a significant component for many dogs with ME (Grobman, Schachtel, et al., 2019). The reasons for the difference in findings may be a result of the differences in study methods. The two studies evaluated different food consistencies and different positioning. As the GES relaxes in response to increases in bolus pressure, these pressures may vary depending on the position and consistency of the diet. While an achalasia-like syndrome may have been present in some dogs in this study, its clinical relevancy is not clear.

Retention of ingesta within the oesophagus was seen commonly in dogs within this study and is presumed to occur in many dogs with ME. This retention could be presumed to lead to the development of esophagitis, and oesophageal mucosal changes have been noted during endoscopy of dogs with ME (Grobman, Hutcheson, et al., 2019). For this reason, many owners of dogs in this study were advised to administer an oral proton pump inhibitor (omeprazole). While this study could not determine if omeprazole as a sole treatment would result in improvement of patients, omeprazole was part of the therapeutic plan for 13 of the dogs in this study and addition of omeprazole could be considered as an adjunct for many dogs with poorly managed ME.

Promotility drugs such as metoclopramide and cisapride do not have effects on the striated muscle of the canine oesophagus and increase

GES pressures (Kempf, Lewis, et al., 2014; Punto et al., 1977). If gastroesophageal reflux was not present, these drugs were advised to be discontinued as they are believed to otherwise be contraindicated in dogs with ME as they can increase GES tone (Quintavalla et al., 2017).

The VF feeding evaluation when combined with other patient information allowed for individual recommendations to be made for the dogs. When followed, the recommendations resulted in a significant decrease in the number of regurgitations per week and a perceived improvement in quality of life in 95% of the dogs without requiring otherwise invasive interventions. While many owners did not elect to follow all recommendations, all but one owner did make at least one management change with some making up to three changes. In five dogs, the only change made was to water administration which resulted in improvements in regurgitation. No other recommendation was the sole change made. This could imply that even a single targeted change in management can have significant impacts on perceived quality of life. This study was unable to determine the independent effects of different management recommendations on frequency of regurgitation events, owner perceived quality of life, or survival. It instead demonstrated the value of a VF feeding evaluation to make recommendations that would be beneficial in the overall management of a dog with ME. Ideally, the findings of this study would be validated against a cohort of dogs with megaoesophagus that are already receiving an optimized management protocol.

Median survival times for dogs with ME are generally considered poor with previous studies noting an association between older age of onset and reduced survival time and overall prognosis (Boudrieau & Rogers, 1985; Harvey et al., 1974; McBrearty et al., 2011; Washabau, 2003). In this, study only three dogs were euthanized due to complications found to be associated with ME, and therefore a valid median survival time could not be calculated (Clark et al., 1992; Leib & Blass, 1984; McBrearty et al., 2011). This emphasizes that with appropriate management changes and individual assessments, survival may be better than previously described. However, a longer prospective study in a larger group of dogs would be needed to confirm this.

Using a larger sample size could allow for a broader characterization of this patient group. However, based on this study, the phenotypic variation of the oesophageal motility and how each dog responded uniquely to the different diet consistencies, it is unlikely that one diet recommendation can fit all dogs with congenital idiopathic ME. Hence, we recommend performing contrast VF on an individual patient basis, especially if they are poorly managed.

Dogs in this study were not tested for hypoadrenocorticism if they were diagnosed or showed signs consistent with megaoesophagus prior to 6 months of age. Current literature has minimal support for development of juvenile onset hypoadrenocorticism in breeds other than Nova Scotia duck tolling retrievers, and concurrent familial hypoadrenocorticism and megaoesophagus in a puppy less than 6 months of age have never been reported (Haines, 2019; Hughes et al., 2007).

At this time, there is a lack of evidence in the veterinary literature describing the sensitivity and specificity of VF for detecting oesophageal dysfunction or other related concerns such as gastroesophageal reflux or GES dysfunction, especially with a single

videofluoroscopic evaluation. There is a possibility that by only evaluating dogs with ME during a single day, some abnormalities could be missed. Also, there could be variability in the findings with repeated measurements. Further research looking at repeated VF studies would help to further determine the utility of VF for evaluation of dogs with ME.

The biggest limitation of this study is that it, by necessity, utilized client owned dogs with a potentially life-threatening disease. It was important that the dogs not be put at risk and therefore alterations to the protocols had to be made to ensure the dog's safety. For this reason, smaller meal size and liquid volumes were used to reduce risk of regurgitation of retained material. Liquid consistency was given first and not randomized due to concerns for a higher likelihood of aspiration if regurgitated. A previous study found that liquid was likely to be cleared into the stomach when followed by meals so this was deemed a safer approach (Haines et al., 2019). Also, an affected control group was not used in this study so as to not deny needed care to any of the dogs with ME. Instead, a healthy comparison group was used to demonstrate expected ECT in dogs while in an upright position with the specific diet consistencies used in this study, as this has not been previously reported in the literature. A useful control group for future studies may be a population of dogs with ME that are already receiving the currently recommended treatment protocol (i.e., sildenafil, omeprazole, and a diet consistency based on trial and error). Finally, this study did not assess if longer time spent vertical would result in better clearance due to concerns for the comfort of the dogs and to minimize stress.

Given the single visit design of this study, all recommendations for management were made simultaneously and owners had the freedom to decide which, if any, management changes they would institute. For this reason, this study is not able to determine which individual management change resulted in improvements in regurgitation frequency or perceived quality of life in the dogs and cannot rule out the potential that improvements seen were due to multiple or cumulative factors. Further research assessing each management change individually, with repeat follow-up might better elucidate their individual impact. The follow-up period was within 3–8 weeks after the study, and it is possible that in the case of young dogs, that improvement in oesophageal function or resolution of ME could have occurred during or after that time, thus contributing to improvements seen in the study. Continued follow-up, ideally using VF, would help to better characterize this possibility. Owners were not required to keep a specific log of daily regurgitation events which could have resulted in some recall bias. Additionally, the quality of life scoring used in this study was based on owner perception of their pet overall with guidance from provided criteria instead of a validated quality of life scoring system. At this time, a validated quality of life scoring system does not exist for dogs with ME.

5 | CONCLUSION

In this study, no single type of diet consistency yielded consistently improved ECT in all dogs. A VF feeding evaluation may be a useful tool

in assessing the ideal food consistency for individual dogs with ME. The feeding evaluation was a simple and non-invasive procedure, and the management changes suggested based on this assessment resulted in a reduction in regurgitation episodes and improvement in perceived quality of life. A VF feeding evaluation should be considered as part of an overall management plan in dogs with idiopathic congenital ME, especially in dogs that are poorly managed.

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CONFLICT OF INTEREST

Authors declare no conflict of interest.

ETHICS STATEMENT

The animal use procedures were approved by the Institutional Animal Care and Use Committee (IACUC) of Washington State University.

AUTHOR CONTRIBUTIONS

Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, writing—original draft and writing—review and editing: Janne Lyngby. *Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, supervision, writing—original draft and writing—review and editing:* Jillian M. Haines. *Formal analysis, methodology, software, writing—original draft and writing—review and editing:* Sarah Guess.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1002/vms3.821>.

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