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Management and outcomes of 13 dogs treated with a modified Heller myotomy and Dor fundoplication for lower esophageal sphincter achalasia-like syndrome

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Abstract

Objective: To report the management and outcomes of dogs treated for lower esophageal sphincter achalasia-like syndrome (LES-AS) with modified Heller myotomy, Dor fundoplication, and with the use of a temporary gastrostomy tube.

Study design: Retrospective.

Sample population: Thirteen client-owned dogs.

Methods: Medical records and a client survey were used to assess frequency of vomiting/regurgitation, quality of life (QoL), bodyweight, and feeding modifications at the following time points: prior to referral, postoperatively from discharge to first recheck (4-6 weeks), and from first recheck to survey (48 months). Postoperative and gastrostomy tube complications were surveyed and recorded. Pretreatment and 4-6 weeks postoperative videofluoroscopic swallow studies (VFSS) were compared. Two-sided *t*-tests were used to compare outcomes between survey time points.

Results: Postoperative VFSS scores (available in 9 dogs) improved over preoperative scores in 6 dogs, and 12/13 dogs survived to discharge. One dog was euthanized 3 days postoperatively due to aspiration pneumonia. Postoperative gastrostomy tube complications occurred in half of the dogs that survived to discharge. According to the owners, scores assigned to vomiting/regurgitation improved by 180% ($P = .004$), QoL by 100% ($P = .004$), and bodyweight by 63% ($P = .035$).

Conclusion: Modified Heller myotomy with Dor fundoplication and the use of a temporary gastrostomy tube improved clinical signs and owners' perceived quality of life in half of the dogs treated for LES-AS in our clinical setting. Oral sildenafil therapy discontinued postoperatively suggests that surgery was equally efficacious.

Abbreviations: BCS, body condition score; BTA, botulinum toxin A; GER, gastroesophageal reflux; IQR, interquartile range; LES, lower esophageal sphincter; LES-AS, lower esophageal sphincter achalasia-like syndrome; QoL, quality of life; RER, resting energy requirement; VFSS, videofluoroscopic swallow studies.

Clinical significance: Modified Heller myotomy with Dor fundoplication and temporary gastrostomy tube is a treatment option with potentially sustained benefits for dogs that have LES-AS.

1 | INTRODUCTION

Lower esophageal sphincter achalasia-like syndrome (LES-AS) in dogs is similar to lower esophageal sphincter (LES) achalasia in people.^{1,2} Both disorders result in functional obstruction of the LES, leading to retention of saliva and ingesta in the esophagus with concurrent esophageal dilation and disruption of esophageal peristalsis.^{1–5} In people, treatment options for LES achalasia include mechanical dilation, functional dilation with botulinum toxin A (BTA) injections, and modified Heller myotomy with Dor fundoplication, or a combination of treatments.^{2,3,6–10} In dogs, mechanical dilation in conjunction with functional dilation (BTA injections) has provided temporary clinical improvement for an average duration of 40 days, and surgical intervention using the modified Heller myotomy with Dor fundoplication appeared to have provided persistent clinical benefits with a median postoperative follow up of 7 months in 6 dogs.²

The objective of this study was to report the management and outcome of dogs treated for LES-AS with modified Heller myotomy, Dor fundoplication, and use of a temporary gastrostomy tube. We hypothesized that a modified Heller myotomy with Dor fundoplication in dogs with LES-AS would result in improved free-feeding videofluoroscopic swallow study (VFSS) scores compared to initial VFSS scores. We further hypothesized that this surgery would achieve sustained postoperative improvement in clinical signs such as a reduction in regurgitation/vomiting episodes, improved quality of life (QoL), and weight gain compared to prior to referral clinical status as perceived by the owner. Lastly, we hypothesized that complications associated with gastrostomy tubes would be more prevalent than complications associated with the primary surgery.

2 | MATERIALS AND METHODS

2.1 | Case selection and criteria

Medical records were retrospectively reviewed for dogs presented to the University of Missouri Veterinary Health Center from 1 July 2015 to 1 January 2021 and subsequently diagnosed with LES-AS. Dogs were included if the following criteria were met: (1) medical record documentation of a diagnosis of LES-AS by free-feeding VFSS; (2) documented clinical improvement via repeat free-

feeding VFSS after targeted treatment by LES mechanical (pneumatic or bougienage) dilation in conjunction with LES BTA injection or oral sildenafil (2 mg/kg every 8 h) trial; and (3) subsequent performance of modified Heller myotomy with Dor fundoplication. Dogs that were diagnosed with LES-AS and did not receive surgery for LES-AS were excluded from this study. Oral medical therapies such as sildenafil were discontinued at time of surgery. Medical records review and results of a phone-based client survey (Appendix) were used to assess the clinical response to the modified Heller myotomy with Dor fundoplication for the treatment of LES-AS. Results of the VFSS, type of medical management, and bodyweights were recorded at initial referral exam, recheck after medical management, and recheck after surgery. The gastric filling score system used to evaluate VFSS results was as follows: small (<25%), medium (25%-75%), and large (>75%) amount of filling.² Survey questions targeted each of the following time points: (1) prior to referral, (2) at recheck examination 4 to 6 weeks after surgery, and (3) from recheck to the time of phone survey (March 2021) or death. Frequency of vomiting/regurgitation and QoL were assessed by the owner using a 5-point scale (1 being frequent vomiting/regurgitation or poor QoL and 5 being almost never vomiting/regurgitating or good QoL). The owner's perception of the dog's bodyweight was scored as 1 of 3 descriptors: underweight, average, and overweight; each term was assigned a numerical value 1, 2, and 3, respectively. Owners were queried about current food consistency and feeding modifications (compared to before referral) that were made after gastrostomy tube removal. Owners were asked to describe any postoperative complications and were specifically asked to describe complications associated with the gastrostomy tube. Complications were categorized as major (ie, aspiration pneumonia, otherwise requiring hospitalization, or euthanasia) or minor (ie, not requiring hospitalization). Lastly, owners were asked if they would make the same decision to have the surgery performed in retrospect and, if not, they were asked why they would decline the procedure. Data were compiled and descriptive statistics were reported. Normality of data was tested with the D'Agostino-Pearson omnibus test. For parametric data, mean values and their SDs were reported, and for nonparametric data, the median values with interquartile range (IQR) were reported. Client survey results from prior to referral for vomiting

scores, QoL scores, and weight measurements were compared with those obtained at the time of recheck to survey completion or death. Comparison was performed with a Wilcoxon matched pairs signed rank test. All comparisons were 2 sided with significance set at $P < .05$. Data were produced and normality testing performed with statistical software (GraphPad Prism 9, GraphPad Software, San Diego, California).

2.2 | Surgical description

Each dog was placed in dorsal recumbency and prepared from cranial to the xyphoid to caudal to pubis with wide lateral margins to the level of the transverse processes to accommodate placement of a gastrostomy tube intraoperatively. Positioning on the operating table facilitated intraoperative esophagoscopy with the patient facing opposite the anesthesia equipment at the caudal edge of the table. A standard ventral midline celiotomy was performed and an appropriately sized Balfour retractor was placed to assist in retracting the body wall. A 2-0 nylon stay suture was placed in the body of the stomach approximately 5 cm caudal to the esophagogastric junction to aid manipulation and facilitate caudal traction of the stomach. The left triangular ligament was transected with monopolar electrosurgery to allow movement of the left lateral and medial liver lobes to the right and improve exposure of the esophageal hiatus, cardia, and cardiac notch. Intraoperative esophagoscopy (with a 5 mm × 65 mm Storz bidirectional intubation fiberscope, Tuttlingen, Germany) was performed to localize the LES. The location of the LES was marked with monopolar electrosurgery on the serosa of the stomach at the esophagogastric junction. The mark extended orad to the distal esophagus, which provided a visual myotomy guide to the surgeon. The myotomy started at the caudal aspect of the planned incision approximately 3 cm caudal to the LES on the stomach. The mucosal slip was palpated at the site on the stomach and Metzenbaum scissors were used to incise the serosa and muscularis, exposing the intact submucosal surface. The incision was extended cranially with a vessel sealing device (Ligasure small jaw open sealer/divider, Medtronic, Minneapolis, Minnesota) to approximately 3 cm cranial to the LES for a total myotomy length of 6 cm (Figure 1A,B). Assessment of residual muscle fibers over the myotomy site was accomplished by retromucosal illumination via intraoperative esophagoscopy, and any remaining muscle fibers were transected (Figure 1C). Next, Dor fundoplication was completed by folding the fundus of the stomach over the myotomy site and suturing it in place with 2-0 polydioxanone suture on a taper needle. First, the seromuscular

layer of the stomach was sutured to the left incision edge of the myotomy using a continuous suture pattern moving from caudal to cranial, continuing to the diaphragm and incorporating the diaphragm immediately before tying the suture (Figure 2A,B). The fundus was subsequently rolled over the myotomy and sutured to the right incision edge using a similar continuous pattern but progressing from cranial to caudal (Figure 2C). As a result, the serosal surface of the gastric fundus covered the exposed esophageal submucosa (Figure 2C). If the diaphragm was inadvertently compromised during creation of the myotomy, repair and reestablishment of intrathoracic negative pressure was performed with polydioxanone suture at surgeon's discretion to repair the defect, and a 60 ml syringe with a 3-way stop cock attached to a 21-gauge butterfly catheter was inserted through the repaired diaphragm to aspirate interpleural air. Patency of the LES was verified by esophagoscopy visualization. A mushroom tip silicone feeding tube (PEG feeding tube-silicone, ICU Medical, San Clemente, California) was used in all dogs with a size 20-24 Fr selection at the surgeon's discretion. The gastrostomy tube was placed by passing Carmalt or Kelly forceps from a stab incision in the peritoneum/body wall to the skin and making a second stab incision in the skin over the forceps. The decision to place a right versus left gastrostomy tube was at the surgeon's discretion. The forceps were then used to pull the mushroom tip of the tube through the skin and body wall into the abdominal cavity. A purse string suture was placed in the wall of the stomach; a stab incision was made in the stomach at the center of the purse string, and the tip of the tube was placed through the incision into the lumen of the stomach. Then, the purse string suture was tied, and the stomach was tacked to the body wall with 4 interrupted sutures. After the tube was pulled such that the mushroom was against the stomach and body wall, the external portion of the gastrostomy tube was anchored to the external body wall with 4 friction sutures using 2-0 nylon suture, as described.¹¹ Briefly, each friction suture was a nonabsorbable suture incorporating the skin and underlying muscle fascia. An initial square knot was tied against the skin. Then, the gastrostomy tube was placed on the square knot and the suture was tied around the tube with a surgeon's knot, indenting the tube but not occluding the lumen, followed by a square knot. The first friction suture was started approximately 1 cm from the tube site exit. The subsequent 3 friction sutures were placed as the first one and approximately 1 cm apart. The gastrostomy tube allowed feeding during the initial 4 to 6 weeks of recovery; owners were instructed to give nothing orally during this recovery period. Standard closure of the celiotomy was performed. Once the dog recovered from anesthesia, the

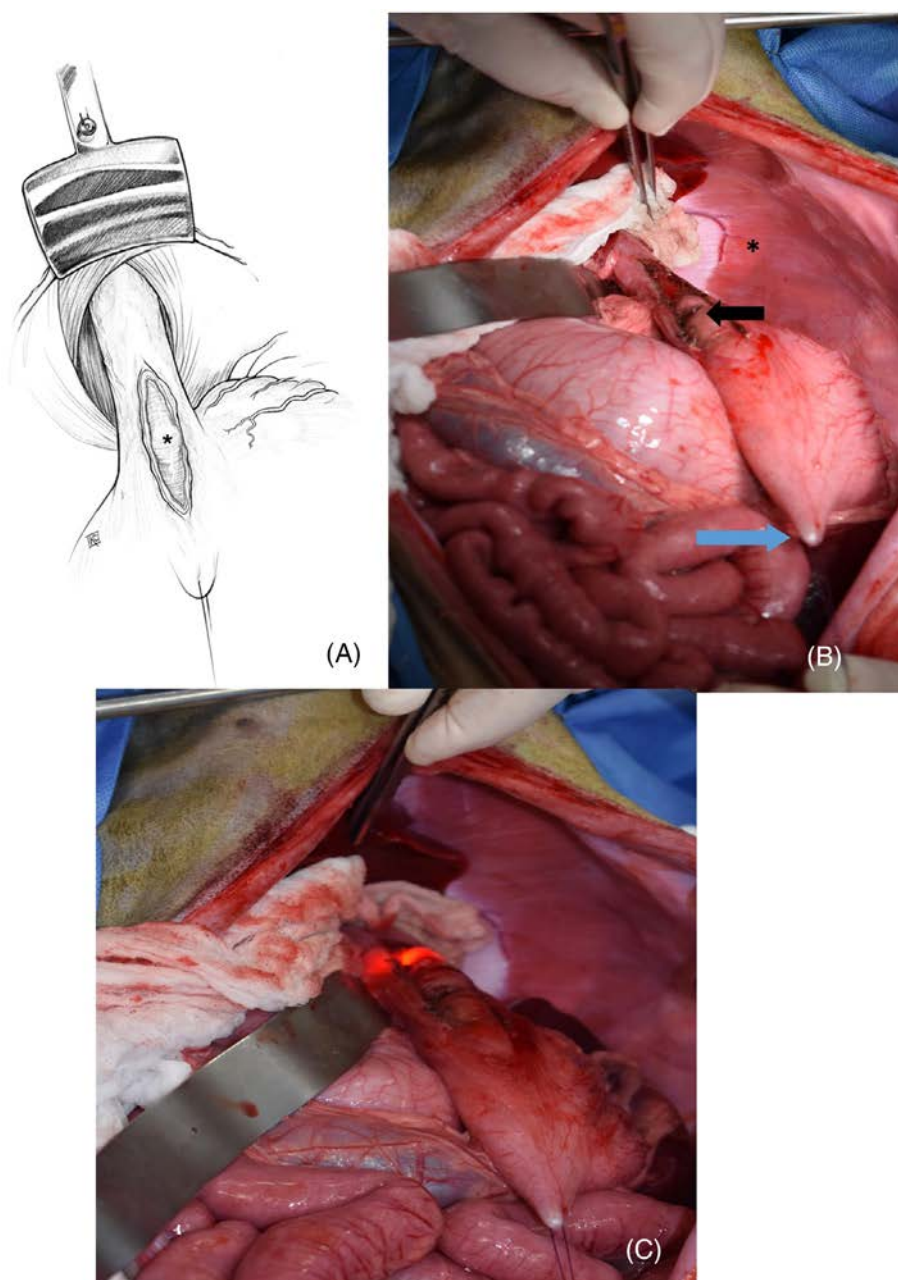


FIGURE 1 (A) The modified Heller myotomy incision through the serosa and muscularis of the caudal aspect of the esophagus to include the lower esophageal sphincter and the cardia of the stomach. The asterisk denotes the bulge of the submucosa. (B) Intraoperative photograph like the anatomic drawing in (A) with modified Heller myotomy created in the caudal esophagus and cardia of the stomach. The solid black arrow indicates the bulge of the underlying submucosa after the myotomy. An asterisk indicates the left pars costalis of the diaphragm. A malleable retractor, DeBakey thumb forceps, and laparotomy sponge are retracting the left medial and lateral liver lobes to the right of the patient for better visualization. A solid blue arrow denotes a stay suture with caudal traction on the stomach. (C) Retromucosal illumination via esophagoscopy to identify any remaining muscle fibers requiring transection after creating the modified Heller myotomy.

nutrition service conducted a water test, administering a 5 ml/kg volume of water through the gastrostomy tube, and monitoring it for signs of nausea and vomiting/regurgitation. If the water test was tolerated, feeding was started the day after surgery at a quarter of the dog's calculated resting energy requirement (RER) divided over 4 to 6 feedings per 24 h period. If feedings were tolerated, the amount was increased over 7 days to a targeted 1.2 RER. A commercial diet (Purina EN, Nestlé Purina, Vevey, Switzerland), blended to a consistency amenable for administration through the gastrostomy tube, was used in all dogs. Gastrostomy tubes were recommended to remain in place until the VFSS recheck 4-6 weeks post-operatively, and until successful transition from

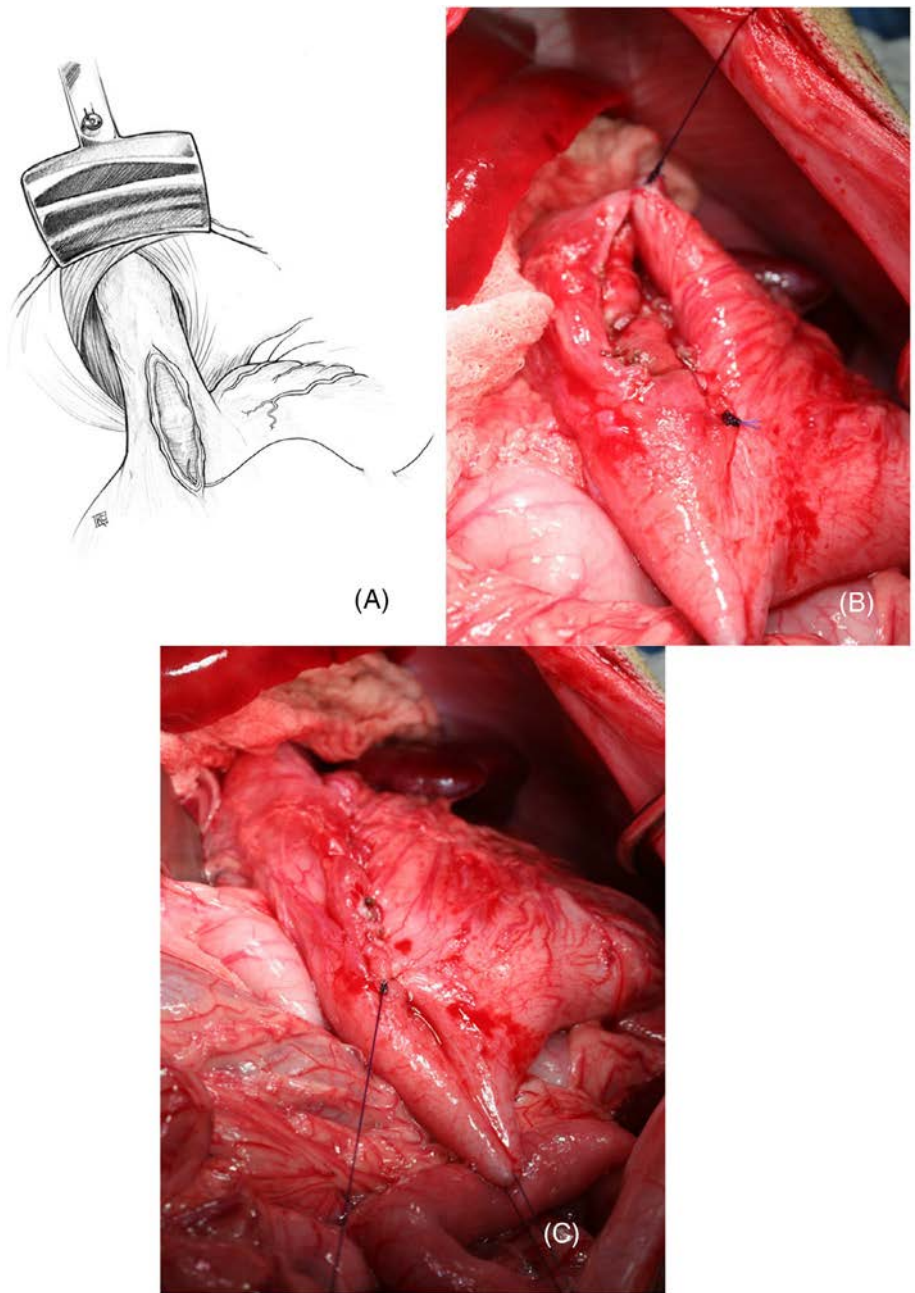
gastrostomy tube to oral feedings occurred. Successful transition to oral feedings was defined as the ability to consume sufficient calories orally to maintain or gain bodyweight as appropriate to achieve or maintain the desired body condition, without persistent clinical signs of vomiting/regurgitation.

3 | RESULTS

3.1 | Demographics

Thirty-nine dogs were initially identified with a diagnosis of LES-AS. Thirteen dogs met the inclusion

FIGURE 2 (A) An anatomic drawing of the initiation of Dor fundoplication with the passage of the suture from the fundus of the stomach to the caudal apex of the modified Heller myotomy incision. A Balfour retractor is depicted cranially with the caudal esophagus crossing the esophageal hiatus into the cardia of the stomach. (B) Half of a Dor fundoplication completed, with the fundus of the stomach sutured to the left incisional edge of the myotomy in a simple continuous pattern with absorbable suture. The last suture passage engaging the diaphragm is difficult to visualize in this photograph. (C) Completed Dor fundoplication with the fundus of the stomach sutured to both edges of the modified Heller myotomy covering the exposed submucosa.



criteria for this study, which included 6 dogs reported in Grobman et al.,² which had surgery. Twenty-six dogs did not have surgery and were excluded from the study for the following reasons: failing medical management, owners electing to not pursue surgery, or euthanasia. Breeds included German shepherd dog ($n = 3$), Labrador retriever ($n = 2$), and 1 each: Dachshund, shar pei, Pudelpointer, golden retriever, Doberman pinscher, Chihuahua, and Australian shepherd. Six dogs were male (5 neutered, 1 intact) and 7 female (4 spayed, 3 intact). Median (range; IQR) age at presentation for surgery was 24 months (7-144; 12-60).

3.2 | Medical records data

All 13 dogs were diagnosed with megaesophagus with concurrent esophageal hypomotility or amotility at initial referral exam via VFSS evaluation, using the VFSS outcome parameters outlined in Grobman et al.² (Table 1). Table 1 contains subsequent VFSS results after instituting medical management and postoperative surgical recheck along with administered treatments, major and minor complications, duration of clinical signs, food consistency, and feeding modifications. All dogs that received oral sildenafil preoperatively (6 dogs) were able to discontinue administration postoperatively.

3.3 | Client survey

Thirteen owners were called to complete the survey; 2 owners were unable to be contacted and, therefore, those 2 dogs were lost to long-term follow up. One dog was euthanized prior to discharge from the hospital due to postoperative complications associated with aspiration pneumonia, and 1 was euthanized 337 days postoperatively due to aspiration pneumonia but both owners were available for the telephone survey. Median (range; IQR) days from recheck to survey completion or death was 337 (3-1452; 242-1427) days. At least 1 episode of pneumonia was diagnosed and treated in 6/13 of dogs prior to referral for surgery with a range of 1 to 8 episodes (Table 1). Mean ($\pm$ SD) scores for frequency of vomiting/regurgitation were 1.4 ($\pm$ 0.6) prior to referral ($n = 12$), 3.8 ($\pm$ 1.2) from surgery to recheck ($n = 12$), and 3.8 ($\pm$ 1.1) from the recheck to survey completion ($n = 10$). Mean ($\pm$ SD) QoL scores were 2.4 ($\pm$ 1.1) prior to referral ($n = 12$), 3.5 ($\pm$ 0.9) from surgery to recheck ($n = 12$), and 4.8 ($\pm$ 0.4) from recheck to survey completion ($n = 10$). Mean ($\pm$ SD) scores for perceived bodyweight were 1.2 ($\pm$ 0.4) prior to referral ($n = 12$), 1.3 ($\pm$ 0.4) from surgery to recheck ($n = 12$), and 2 ($\pm$ 0.6) from recheck to survey completion ($n = 10$) (Table 2). Food consistency as described by the owner at the time of the survey included 7/10 soft gruel/smoothie, 2/10 combination soft gruel/dry mix, and 1/10 dry (Table 1), with 7/10 respondents indicating that the consistency being fed was required to control episodes of vomiting/regurgitation. In addition to food consistency, owners reported use of feeding modifications to assist in reducing vomiting/regurgitation; 4/10 reported use of a Bailey chair for dogs, 3/10 reported use of elevated feed bowls, 2/10 reported replacement and intermittent long-term use of a gastrostomy tube, and 1/10 reported use of a Bailey chair for dogs in combination with an intermittent gastrostomy tube to feed their pet long term (Table 1). Owners' responses to survey questions about medications were inaccurate and incomplete due to failure to remember.

3.4 | Outcome

Of the 13 dogs that went to surgery, 12 survived to discharge. The mean (range) of patient bodyweights was 16.9 kg ($n = 13$; 2.3-32.7) at initial exam, 17.6 kg ($n = 13$; 2.6-33.5) postmedical management, 17.9 kg ($n = 9$; 5-29.3) after postsurgical management, and 20.7 kg ($n = 5$; 5.7-35.5) greater than 2 months after surgery. This equated to an average increase in bodyweight from the initial exam to postmedical management, postmedical management to postsurgical management, and postsurgical management to greater than 2 months after surgery of +4.7%, +5.7%,

and +19.8%, respectively. Client survey results from prior to referral for vomiting, QoL, and perception of bodyweight were compared to those obtained from recheck to survey completion or death, with a mean of 537 days after surgery (Table 2). There was improvement in vomiting/regurgitation ($P = .004$), QoL ($P = .004$), and perception of bodyweight ($P = .035$) scores. All dogs showed improved passage of contrast through the LES from initial VFSS evaluation to the recheck after medical management VFSS evaluation, despite no change in gastric filling scores. Of the 9 dogs that had VFSS at the postoperative recheck, 6 demonstrated further improvement in gastric filling scores, improving from small to medium, while the other 3 dogs were static, in comparison with the recheck VFSS results after initiation of medical management. For the dogs that had the gastrostomy tube removed, the mean (range) of days the gastrostomy tube was in place before removal was 62 (29-129) days. Use of feeding modifications increased from initial referral exam to time of survey (Table 1). Owner perception survey results showed that frequency of vomiting/regurgitation, QoL, and bodyweight parameters improved after surgical intervention compared to the parameters prior to referral. Nine of 11 owners stated that they would have the procedure done again, whereas 2 of 11 said that they would not proceed with the surgery. The owner of dog #9, whose pet did not survive to discharge, cited the risk of complications being too great in retrospect. The owner of dog #4 cited a lack of perceived efficacy in improving clinical signs and QoL.

3.5 | Complications

Intraoperative complications (inadvertent pneumothorax during myotomy) occurred in 2 dogs, without any associated postoperative complications. One dog developed aspiration pneumonia in the postoperative period and was humanely euthanized, and another patient was euthanized after developing aspiration pneumonia approximately 1 year after surgery. Of the 12 dogs that survived to discharge, major postoperative complications occurred in 5 dogs (including the dog that had aspiration pneumonia almost a year postoperatively), and minor complications occurred in 2 dogs (Table 1). Other than the dog with aspiration pneumonia that resulted in euthanasia 337 days after surgery, all 4 major and 2 minor postoperative complications of survivors were related to the gastrostomy tube. All gastrostomy tubes were placed on the left side, except for 1 placed on the right side. The right sided gastrostomy tube was placed at the surgeon's discretion as a means of concurrently creating a right sided gastropexy for gastric volvulus prophylaxis. Three of the 4 major complications required some

TABLE 1 Clinical data and follow-up information for 13 dogs (listed in chronological order), which were diagnosed with megaesophagus and esophageal hypomotility or amotility and underwent modified Heller myotomy with Dor fundoplication for treatment of lower esophageal sphincter achalasia-like syndrome

Patient Signalment	Major complications	Minor complications	Length of follow-up	Owner reported duration of clinical signs prior to surgery	Owner reported occurrence of aspiration pneumonia before referral	Initial referral exam		Recheck medical management exam		Recheck postoperative exam		At phone survey	
						VFSS evaluation	Administered treatment	Current owner feeding modifications	VFSS evaluation	Administered treatment	VFSS evaluation based on VFSS feed consistency	Current owner feeding modifications	Current owner feeding consistency
1 ^a	7 months FS Australian shepherd	None	None	1215 ^b 6 months	0	Minimal passage of contrast through LES; gastric filling grade small	Dilation, Botox injection, PEG tube	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	Improved passage of contrast through LES; gastric filling grade medium	Liquid	Lost to follow up
2 ^a	12 years MN Chihuahua	None	None	33 ^b 24 months	2	Minimal passage of contrast through LES; gastric filling grade small	Dilation, Botox injection, PEG tube	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	No post-op swallow study	N/A	Gruel
3 ^a	11 years FS Miniature Schnauzer	Leakage around gastrostomy tube site requiring surgical correction	None	690 ^b 8 months	3	Minimal passage of contrast through LES; gastric filling grade small	Dilation, Botox injection	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	Static passage of contrast through LES; gastric filling grade small	Gruel	Feeding tube and Bailey chair
4 ^a	11 months FS Doberman Pinscher	None	None	1452 4 months	1	Minimal passage of contrast through LES; gastric filling grade small	Dilation, Botox injection, PEG tube	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	No post-op swallow study	N/A	Gruel
5 ^a	3.5 years FS Golden Retriever	Feeding tube came loose and end of tube had to be cut; spent night in hospital to ensure passage of tube tip	None	1350 7 months	0	Minimal passage of contrast through LES; gastric filling grade small	Dilation, Botox injection	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	Improved passage of contrast through LES; gastric filling grade medium	Gruel	Gruel

(Continues)

TABLE 1 (Continued)

Patient Signalment	Major complications	Minor complications	Length of follow-up	Owner reported duration of clinical signs prior to surgery	Owner reported occurrence of aspiration pneumonia	Initial referral exam		Recheck medical management exam		Recheck postoperative exam		At phone survey	
						VFSS evaluation	Administered treatment	Current owner feeding modifications	VFSS evaluation	Administered treatment	VFSS evaluation based on VFSS feed consistency	Current owner feeding modifications	Current owner feeding consistency
6 ^a	2 years MI Pudelpointer	Developed aspiration pneumonia approximately 1 year after surgery resulting in euthanasia	None	337 ^b 5 months	0	Minimal passage of contrast through LES; gastric filling grade small	Dilation, Botox injection	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	No post-op swallow study	N/A	Dry
7	5 years MN Shar Pei	None	None	738 40 months	0	Minimal passage of contrast through LES; gastric filling grade small	Dilation, Botox injection	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	Improved passage of contrast through LES; gastric filling grade medium	Bailey chair	Gruel
8	6 years FS Dachshund	Developed aspiration pneumonia in the immediate postoperative period resulting in euthanasia	None	3 ^b 56 months	8	Minimal passage of contrast through LES; gastric filling grade small	Sildenafil ^c	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	No post-op swallow study; euthanized postoperatively	N/A	N/A
9	2 years MN Labrador retriever	None	None	444 18 months	0	Minimal passage of contrast through LES; gastric filling grade small	Sildenafil ^c	Upright feedings	Improved passage of contrast through LES; gastric filling grade small	Surgery	Improved passage of contrast through LES; gastric filling grade medium	Bailey chair	Gruel
10	1 year FI German shepherd dog	Gastrostomy tube prematurely dislodged 9 days after surgery requiring surgical replacement	None	50 ^b 6 months	0	Minimal passage of contrast through LES; gastric filling grade small	Sildenafil ^c	Bailey chair	Improved passage of contrast through LES; gastric filling grade small	Surgery	Static passage of contrast through LES; gastric filling grade small	Bailey chair	Lost to follow up

TABLE 1 (Continued)

Patient Signalment	Major complications	Minor complications	Length of follow-up	Owner reported clinical signs prior to surgery (number of times)	Owner reported occurrence of aspiration pneumonia	Initial referral exam		Recheck medical management exam		Recheck postoperative exam		At phone survey	
						VFSS evaluation	Administered treatment	Current owner feeding modifications	VFSS evaluation	Administered treatment	VFSS evaluation based on VFSS feed consistency	Current owner feeding modifications	Current owner feeding consistency
11	3 years MN Labrador retriever	Gastrosomy tube migration that caused a duodenal perforation and intestinal plication requiring surgical correction	175	34 months	3	Minimal passage of contrast through LES; gastric filling grade small	Sildenafil ^c	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	Improved passage of contrast through LES; gastric filling grade medium	Elevated feeding bowl	Elevated feeding bowl
12	9 months FI German shepherd dog	None	76	7 months	0	Minimal passage of contrast through LES; gastric filling grade small	Sildenafil ^c	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	Static passage of contrast through LES; gastric filling grade small	Bailey chair	Bailey chair
13	1 year MN German shepherd dog	None	66	3 months	1	Minimal passage of contrast through LES; gastric filling grade small	Sildenafil ^c	None	Improved passage of contrast through LES; gastric filling grade small	Surgery	Improved passage of contrast through LES; gastric filling grade medium	Elevate feeding bowls	Elevated feeding bowl

Note: Length of follow up is the time (days) from surgery to last reported observation of the dog as determined at the time of survey. Major complications were defined as requiring surgical intervention, hospitalization, or euthanasia. Minor complications were defined as those that could be managed on an outpatient basis.

Abbreviations: LES, lower esophageal sphincter; N/A, no data available at that time point; PEG, percutaneous endoscopically placed gastrostomy; VFSS, videofluoroscopic swallow study [Gastric filling was graded as small (<25%), medium (25%–75%), or large (>75%)²].

^aDogs previously reported by Grobman et al.²

^bThe owner was unable to be contacted or the dog was deceased at the time of survey; therefore, the last available recorded date the dog was confirmed to be alive was used.

^cDosage of sildenafil used by internal medicine service 2 mg/kg PO q8 h.

TABLE 2 Mean scores for vomiting/regurgitation, quality of life (QoL), and bodyweight for 13 dogs that had modified Heller myotomy with Dor fundoplication at the following time points: prior to referral, at recheck examination 4 to 6 weeks after surgery (median 35, range 8-94 days), and at postoperative follow up (median 337, range 66-1452 days) based on client survey

Dog	Prior to referral ^a			From discharge to 1st recheck ^b			From 1st recheck to survey ^c		
	Vomiting/ regurgitation	QoL score	Weight score	Vomiting/ regurgitation	QoL score	Weight score	Vomiting/ regurgitation	QoL score	Weight score
1 ^d	1	3	1	3	4	2	^e	^e	^e
2 ^d	1	2	1	3	3.5	1	3.5	4	1
3 ^d	2	5	2	5	4	1	5	4	1
4 ^d	1	1	1	1	1	1	1	5	2
5 ^d	1	1	1	5	3.5	1	3.5	5	2
6 ^d	3	3	1	5	4	2	4	5	2
7	1	2	1	3	3	1	4.5	5	2
8	1	1	2	^f	^f	^f	^f	^f	^f
9	1	1	1	5	5	2	3.7	4.7	3
10	2	3	1	3.5	4	1	^e	^e	^e
11	1	3	2	3	3	1	3	5	3
12	1.5	3	1	5	4	1	5	5	2
13	1	3	1	4	3.5	1	4.5	5	2
Mean (SD)	1.35 (±.61)	2.38 (±1.11)	1.23 (±0.37)	3.79 (±1.21)	3.54 (±0.92)	1.25 (±0.43)	3.77 (±1.09)	4.77 (±0.39)	2.00 (±0.63)

Note: Clients rated vomiting/regurgitation and quality of life on a 5-point scale (1 = poor; 5 = excellent). Clients rated bodyweight as underweight (1), average (2), and overweight (3). Statistical comparisons were performed only between "prior to referral" and "from first recheck to survey" due to the use of a gastrostomy tube in all dogs during the period "from discharge to first recheck".

^aSurvey scores reflect owner assessment prior to first referral examination.

^bSurvey scores reflect owner assessment from surgery discharge to first postoperative recheck examination.

^cSurvey scores reflect owner assessment >2 months postoperatively or death.

^dDogs previously reported by Grobman et al.²

^eLost to follow up.

^fEuthanized in the immediate postoperative period.

degree of surgical intervention while the fourth was hospitalized overnight for observation: tube leaking ($n = 1$), tube migration with duodenal perforation (1 right sided tube), tube dislodgement requiring replacement ($n = 1$), tube loosening ($n = 1$) (Table 1). In the dog with tube leakage, the leakage was noted to be around the tube and not intraperitoneal. This dog was subsequently placed under general anesthesia to have the gastrostomy tube removed and the stoma site externally explored prior to the placement of a larger bore gastrostomy tube. The dogs with tube migration and premature dislodgement required more extensive surgical intervention with exploratory celiotomies to make corrections. The dog that experienced the tube loosening did not require surgery; however, the external portion of the gastrostomy tube was cut, and the dog was hospitalized to ensure passage of the remaining gastrostomy tube tip. The 2 dogs that did not require surgery to address a complication were a dog that bit off the administration end of the gastrostomy tube and a dog that had tube patency issues (Table 1).

4 | DISCUSSION

Six of 13 dogs in this report showed improvement in postoperative VFSS scores in comparison with initial VFSS scores, whereas 4/13 were unable to be evaluated (Table 1). Some (3/13) dogs with improved passage of contrast did not have improved VFSS scores (Table 1). Passage of contrast through the LES was a subjective observation with interpretation subject to varying interpretation among different attending clinicians, whereas the VFSS gastric filling score is based on specific criteria. It is therefore not surprising that variation could occur between subjective assessments and criteria-based scores. The VFSS gastric filling score is an objective assessment based on criteria defined in the Grobman report.² Most owners scored their dogs as improved (frequency of vomiting/regurgitation, QoL, and perception of bodyweight) in comparison with the situation prior to referral. Improvements in vomiting/regurgitation, QoL, and perceived bodyweight were based on comparison of survey data between the first time point (prior to referral) and

third time point (long-term follow up) because survey data at the second time point (recheck 4-6 weeks after surgery) would be influenced by the use of the gastrostomy tube for feeding. The first and third survey time points were not influenced by use of a gastrostomy tube, except for 3 dogs that continued to have a gastrostomy tube in place long term. The owners of these 3 dogs reported intermittent use of the gastrostomy tube due to continued intermittent vomiting and failure to maintain weight when transitions to complete oral feedings were attempted. Seven out of 10 dogs did not require tube feedings long term while 3 dogs only had the gastrostomy tube used intermittently, so score changes at the third survey compared to the first survey may be attributed to the surgical procedure and not to the gastrostomy tube. Owners may perceive improvements that do not correlate with objective assessments, so we included VFSS to provide some objectivity. Improvement in gastric filling during VFSS was noted in 6 of the 9 dogs that had diagnostic VFSS preformed, indicating that surgery contributed to increased gastric filling. The other 3 dogs were noted to have static passage of ingesta with small gastric filling scores compared to the VFSS after medical management; this surgical intervention therefore does not appear to result in a setback in clinical status when it is not completely successful. However, there were no postoperative VFSS studies done in 2 of the 3 dogs that continued to use the gastrostomy tube for further comparison. Our hypothesis was supported by improvement in gastric filling scores in half of the dogs that survived to discharge and owner perceived improvement in vomiting/regurgitation, QoL, and bodyweight in more than half of the dogs compared to clinical status prior to referral.

Given the very limited literature available regarding LES-AS in dogs, most of the medical and surgical recommendations have been based on empiric extrapolation of human interventions. The first reported extramucosal cardiomyotomy consisted of 2 incisions through all layers of the anterior and posterior aspects of the esophagus and cardia except the mucosa.¹²⁻¹⁵ Heller's technique was later modified by Zaaijer to a single anterior incision; however, regardless of technique, these patients maintained a high occurrence of reflux esophagitis postoperatively, which eventually led to adding an antireflux procedure (ie, fundoplication).¹⁵⁻¹⁷ The addition of fundoplication reduced postoperative gastroesophageal reflux (GER), making the combined technique (modified Heller myotomy with fundoplication) the gold standard for treatment of LES achalasia in people.¹⁷

The Heller and modified Heller myotomy have been evaluated and used clinically in dogs with varying degrees of success for improving clinical signs associated with lower esophageal motility disorders.^{2,18-20} These

dogs have been successfully treated with mechanical dilation, functional dilation (BTA injections), or oral sildenafil to provide improvement in clinical signs.^{2,21,22} Oral sildenafil is a selective phosphodiesterase type 5 inhibitor that increases the effects of endogenous nitric oxide, resulting in smooth muscle relaxation in select tissues.²¹ Sildenafil has been demonstrated to reduce tone of the LES in human beings and cats, and more recently documented in dogs to lower LES tone.²¹⁻²³ Sildenafil is therefore a less invasive and less expensive medical management alternative to esophageal dilation and BTA injections to determine clinical response for dogs diagnosed with LES-AS. However, medical therapies are temporary solutions that require repetitive treatments or chronic oral administration of medications to sustain clinical improvement.^{2,22} Application of the modified Heller myotomy with Dor fundoplication provides a surgical solution for medically responsive dogs with LES-AS and, as suggested in a previous report, this surgery may provide sustained relief from clinical signs without continued medical therapy.²

In human medicine there is lack of consensus regarding which particular fundoplication is most effective at reducing reflux in conjunction with modified Heller myotomy.^{17,24-26} Currently, a complete fundoplication (Nissen) is not commonly used in people due to increased postoperative dysphagia compared to other fundoplications.²⁶ Some surgeons advocate the Toupet fundoplication (partial posterior) as it keeps the myotomy fibers separated and reduces the possibility of fibrosis and recurrence of dysphagia.²⁶ Others recommend the Dor fundoplication (partial anterior) because there is no posterior dissection, making the procedure quicker and easier to perform while effectively covering the exposed esophageal mucosa to reduce likelihood of fibrosis.²⁶ In this series of dogs, Dor fundoplication was chosen over the Toupet fundoplication for ease of access to the ventral surfaces of the canine esophagus and stomach via ventral midline celiotomy.

Our study included both juvenile and nonjuvenile dogs. The number of nonjuvenile dogs presented for this procedure may seem a bit surprising because idiopathic megaesophagus is considered to be a congenital condition, but dogs can develop adult (7-15 years old) onset idiopathic megaesophagus, although the incidence is unknown.^{27,28} Idiopathic megaesophagus has been incorrectly associated with achalasia in human beings and dogs,²⁷ but improvement in veterinary diagnostic capabilities^{1,2} has allowed identification of a subset of dogs with megaesophagus that indeed have lower esophageal achalasia, and this has been demonstrated in both young and older dogs,² including dogs in the present study.

Modifications in food consistency and other feeding practices were reported by owners to play a considerable

role in helping improve vomiting/regurgitation. Most owner's 7/10 reported that their chosen food consistency was critical for reducing vomiting and/or regurgitation in their dogs, with 9/10 feeding a gruel or softer diet. All owners also reported using a Bailey chair or other forms of elevated feeding to help reduce episodes of vomiting/regurgitation. These findings highlight the importance of dietary and feeding factors in postoperative management of dogs with LES-AS. However, 1/10 of owners in this study reported using a hard kibble diet. Dietary and feeding factors are important to the general population of dogs with LES-AS, but the impact of dog-dependent differences and variations cannot therefore be overlooked. These findings highlight the importance of considering patient differences. Performing VFSS approximately 4 to 6 weeks postoperatively was important to optimizing dietary and feeding recommendations by allowing different food consistencies (dry, wet, gruel) and feeding positions (elevated feeding bowls and upright feedings to simulate a Bailey chair) to be evaluated to determine which food consistency most readily passed through the LES and if feeding positions further improved passage. So, VFSS could help guide veterinarians in the formulation of individualized feeding strategies, as evident with the number of dogs having feeding modifications according to the survey results in comparison with modifications reported at the initial referral exam (Table 1).

Most postoperative complications were related to gastrostomy tubes, which supported our second hypothesis that gastrostomy tube complications would be more prevalent than primary surgical procedure complications. In this report, 6/12 of dogs that survived to discharge experienced a gastrostomy tube complication. However, despite complications, gastrostomy tubes in these dogs allowed improved nutritional support by bypassing the surgical site to support tissue healing. Previous studies with surgically placed gastrostomy tubes have reported a minor complication rate of 26%-75%, a major complication rate of 0%-25%, and an overall complication rate as high as 33.3%.^{29,30} In our study, 2/12 dogs developed minor complications, which is similar to previous reports; major complications occurred in 4/12 dogs and overall complications occurred in half the dogs that survived to discharge, both higher than previous reports.^{29,30} The high tube complication rate warrants further investigation. The 4 major tube complications in this series of dogs appear to be unrelated in mode of failure. One dog traumatically dislodged its gastrostomy tube. One dog experienced leakage around the tube, which has previously been reported as a potential complication of gastrostomy tubes.^{29,30} The tube that came loose and required the tip to be cut has been reported as a complication;²⁹ however, the reason for tube loosening could not be determined because the dog was assessed elsewhere. In

that dog, the presumed mode of failure was slippage through the 4 friction sutures used to anchor the tube to the body wall, which has been described as the primary mode of failure for gastrostomy tubes anchored with 4 friction sutures.¹¹ However, the mode of failure for friction sutures in the referenced study was failure of the first suture with the remaining 3 sutures still intact.¹¹ In the same study, failure of the Chinese finger trap was related to suture breakage at the single anchor point.¹¹ Both anchor methods could fail if technical errors occur during placement but the mode of failure for the Chinese finger trap is complete failure, whereas multiple friction sutures would have to fail for complete failure.¹¹ Either method should be acceptable to anchor the gastrostomy tube, leaving the decision of which to use at the surgeon's discretion. The dog with tube migration into the duodenum was an unusual complication that, as far as the authors' are aware, has not been reported. This gastrostomy tube was placed on the right side for prevention of gastric dilatation-volvulus.³¹ It is possible that a tube in the pyloric antrum, being closer to the duodenum than a tube in the fundus, may be more likely to migrate through the pylorus into the duodenum than a tube anchored on the left side of the body. As such, the authors recommend placement of gastrostomy tubes on the left side to prevent this complication. If a right-sided gastropexy is required, perhaps a technique other than tube gastropexy should be performed. While this unique tube migration has not been reported with tube gastropexies, such tubes are only left in place for just beyond 7 days,³¹ much shorter duration than the gastrostomy tubes in this study. It is recommended that the gastrostomy tube remains in place through the postoperative VFSS and until successful transition from gastrostomy tube to oral feeding. The mean number of days the gastrostomy tube was in place before removal was 62 (range 29-129) days. The variation in gastrostomy tube removal times in this population of dogs may be multifactorial. In some dogs, gastrostomy tube complications required surgical intervention, and this may have contributed to delayed removal. Additionally, individual differences in the clinical impact of megaesophagus within the population may have resulted in variable gastrostomy tube removal times.

Aspiration pneumonia was a persistent risk to patients. More than 50% reported at least 1 episode of aspiration pneumonia prior to referral. Further, the dog that failed to survive to discharge demonstrated that aspiration pneumonia is a potentially fatal postoperative complication. Despite surgical intervention and recovery from surgery, dogs with megaesophagus continue to be predisposed to aspiration pneumonia as apparent from the dog that developed aspiration pneumonia approximately 1 year after surgery.^{21,29,33-35}

The limitations of this study are related to the retrospective nature and reliance on the accuracy of medical records, including the records of 3 dogs that survived to discharge and did not have postoperative VFSS rechecks. Significant geographical distance from the referral institution made rechecks impractical for some. Ideally, it would be helpful to do a VFSS every 6 months to track VFSS parameters and correlate with clinical parameters. The number of dogs included in our study ($n = 13$) was small, including 1 euthanized postoperatively in hospital and 2 lost to long-term follow up. Another limitation was the use of a nonvalidated client survey that relied on owner memory recall. Further, owners were prompted specifically about gastrostomy tube complications, and that prompt may have induced owner bias in the responses and may have overridden recall of other complications that may have occurred. Poor memory recall rendered useless the survey questions regarding specific number and frequency of medications given to the dogs. A significant contributing factor to owner recall was the wide range of days (66-759) from recheck to survey completion. The wide range in ages (several cases younger than a year of age and older than 10 years of age with the majority between 2 and 6 years) made it unclear if age was a factor in response to treatment. Further, body-weight was surveyed as subjective descriptors to the owners in the questionnaire (underweight, average, overweight) and did not use a methodically assigned numerical value for comparison with numerically recorded weights in the medical records. Body condition scores might have been more useful for comparisons with a standardized body condition score (BCS) such as the 9-point scale. However, it was determined that the descriptors used would be more familiar terminology and applicable to the owner, while keeping the length and time of the survey to a practical and manageable level. Finally, food consistency and feeding method strategies were designed in conjunction with the surgical procedure as part of the overall management of LES-AS. While the number of patients utilizing a feeding management strategy increased from initial exam to post surgery, these changes were made to minimize episodes of vomiting/regurgitation. There were no nonsurgical groups for comparison, such as medical management with feeding modifications or gastrostomy tube-only groups. It is therefore unknown if medical management with feeding modifications or gastrostomy tube alone could be successful for dogs with LES-AS. However, the inability to control clinical signs by nonsurgical means prompted the owners to seek a surgical solution. As there were no dogs in this study that responded optimally to surgery alone, it is likely that postoperative feeding modifications will remain necessary for acceptable results. To date only

dogs that have responded to medical management were deemed candidates for surgery on the premise that if the LES did not demonstrate a reduction in tone there would not be a favorable response to surgery. However, there are no data to support that assumption, and a study looking at surgical responses in those dogs that do not respond to medical management would be warranted.

In conclusion, the information from the cohort presented here suggests that modified Heller myotomy with Dor fundoplication and temporary gastrostomy tube is a viable option that may favorably impact the ability to reduce episodes of vomiting/regurgitation, facilitate weight gain, and improve QoL for a subset of dogs with megaesophagus that have LES-AS. The ability to discontinue oral medical therapy postoperatively suggests that surgery was as efficacious as receiving oral sildenafil. Further studies are warranted to optimize management practices and outcomes for LES-AS and its surgical treatment.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to this report.

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APPENDIX

Pet's Name: _____.

Owner's Name: _____.

Surgery Date: _____.

Before referral to specialty hospital

1. On a scale of 1–5 (with 1 being frequently and 5 being almost never in a 24-h period), how frequently did your dog experience vomiting or regurgitation prior to surgery?

2. On a scale of 1–5 (with 1 being poor and 5 being excellent), how would you describe your pet's quality of life prior to surgery?

3. How many medications did your pet receive in a day?

4. On a scale of 1–5 (with 1 being frequently and 5 being almost never), how frequently were medications given to your pet prior to surgery?

5. Was your pet diagnosed and treated for pneumonia before surgery?
Yes/No If yes, how many episodes of treatment with recovery were there? _____
6. How would you describe your pet's weight prior to surgery?
Underweight Average Overweight

Discharge to 1st recheck

1. On a scale of 1–5 (with 1 being frequently and 5 being almost never in a 24-h period), how frequently did your dog experience vomiting or regurgitation?

2. Describe your pet's postoperative complications, if any, on a scale of 1–5 (with 1 requiring hospitalization and 5 no complications/no hospitalization). _____
3. On a scale of 1–5 (with 1 being poor and 5 being excellent), how would you describe your pet's quality of life?

4. How many medications did your pet receive in a day? _____
5. On a scale of 1–5 (with 1 being frequently and 5 being almost never in a day), how frequently were

medications given to your pet?

6. How would you describe your pet's weight?

Underweight Average Overweight

7. Did your pet experience any tube-associated complications?

Yes/No If yes describe _____

Recheck to survey (or to euthanasia)

1. On a scale of 1–5 (with 1 being frequently and 5 being almost never in a 24-h period), how frequently did your dog experience vomiting or regurgitation?

2. On a scale of 1–5 (with 1 being poor and 5 being excellent), how would you describe your pet's quality of life?

3. How frequently were medications given to your pet in a day?

4. On a scale of 1–5 (with 1 being frequently and 5 being almost never in a day), how frequently were medications given to your pet?

5. How would you describe the food consistency eaten by your pet now?
Dry Wet Soft gruel/(smoothie) Liquid
6. Do you feel this consistency is required to control signs of regurgitation?

7. How would you describe your pet's weight?
Underweight Average Overweight
8. Which of the following is being used to feed your pet?
Bailey Chair Elevated Bowl Position Floor Level
Other _____
9. If deceased, did your pet pass or have euthanasia due to disease processes unrelated to LES or symptoms related to LES? Describe any symptoms or persistent complications. _____
10. In hindsight, would you still elect to have surgery performed on your pet?
YES/NO If no, why _____