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Prospective evaluation of an indwelling esophageal balloon dilatation feeding tube for treatment of benign esophageal strictures in dogs and cats

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Background: Despite multiple dilatation procedures, benign esophageal strictures (BES) remain a recurring cause of morbidity and mortality in dogs and cats.

Objective: Investigate the use of an indwelling Balloon Dilatation esophagostomy tube (B-Tube) for treatment of BES in dogs and cats.

Animals: Nine dogs and 3 cats.

Methods: Animals with BES were recruited for our prospective study. Endoscopic and fluoroscopic evaluation of the esophagus and balloon dilatation were performed under general anesthesia, followed by placement of an indwelling B-Tube. The animals' owners performed twice daily at-home inflations for approximately 6 weeks. Repeat endoscopy was performed before B-Tube removal. Animals were reevaluated for changes in modified dysphagia score (MDS) after B-Tube removal.

Results: The B-Tube management was relatively well tolerated and effective in maintaining dilatation of a BES while in place. These animals underwent a median of 2 anesthetic episodes and were monitored for a median of 472 days (range, 358-1736 days). The mean MDS before treatment was $3.1 \pm 0.5/4.0$ and final follow-up MDS were significantly ($P < .0001$) improved at $0.36 \pm 0.65/4.0$. Eleven of 12 animals (91.7%) had improved MDS at the end of the follow-up period, with 8/12 (66.7%) having an MDS of 0/4, 2/12 (16.7%) an MDS of 1/4, and 1/12 (8.3%) an MDS of 2/4. One dog died.

Conclusions and Clinical Importance: The B-Tube offers an effective, and more economical method, and often decreased anesthetic time to repeated balloon dilatation procedures for the treatment of BES in dogs and cats.

KEYWORDS
balloon dilatation, bougienage, esophagus, esophageal stricture

Abbreviations: B-Tube, balloon dilatation esophagostomy tube; BES, benign esophageal stricture; E-tube, esophagostomy tube; LES, lower esophageal sphincter; MDS, modified dysphagia score(s); UES, upper esophageal sphincter.

Study performed at Animal Medical Center, New York, NY 10065.

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1 | INTRODUCTION

Esophageal strictures most commonly are a result of esophagitis after gastroesophageal reflux during an anesthetic event.[1–4] These strictures usually result from scar tissue formation after circumferential mucosal ulceration and erosion, resulting in subsequent luminal compromise. Factors previously implicated in benign esophageal strictures (BES) may include mechanical injuries,[5,6] iatrogenic trauma during surgery or endoscopy, congenital stenosis,[7] and chemical injuries (especially documented in cats).[8,9]

The minimal goal of treatment for BES is restoration of sufficient oral feeding to maintain hydration and nutrition without medical intervention.[10] Treatment options currently include medical management aimed at controlling esophageal reflux and subsequent mucosal damage, enteral nutrition if necessary, mechanical dilatation, stenting, or surgical resection and anastomosis.[2–4,10–14] The current standard-of-care therapy is repeated mechanical dilatation, either by bougienage or balloon dilatation, resulting in improved outcomes in 70%-88% of cases, with many animals requiring multiple treatments.[2–4,12,13] These studies reported a successful outcome (defined differently in different studies) after a mean of 2.2 to 4.5 treatments (Table 1). The dilatation procedures and repeated general anesthesia events add cost and risk of potential further esophageal reflux. When data for these 2 treatment methods is more critically reviewed, complete resolution of clinical signs, defined as the ability to ingest food of any consistency, is only noted in 12%-23% of cases.[2–4]

Esophageal stenting has been investigated as a possible single-stage solution to improve BES treatment outcomes. Although short-term dysphagia was improved in dogs, a recent study resulted in 7/9 dogs (77.8%) experiencing major complications after stent placement.[10] Complications included stent migration, hyperplastic tissue ingrowth or overgrowth, dysphagia, gagging and perceived discomfort, and stricture recurrence. We designed the Balloon Dilatation esophagostomy tube (B-Tube) (Esophageal Feeding Tube with Balloon Dilator, Mila International Inc., Florence, Kentucky) with Mila International, Inc. to maintain more frequent (twice daily) stricture dilatations compared to current commonly performed intermittent dilatation therapies, but to avoid the persistent dilatation and subsequent gagging and regurgitation experienced by many animals with esophageal stents. This approach is similar to the well-described concept of esophageal self-dilatation in human patients with BES. This procedure is typically performed adjunctively with traditional physician-performed dilatations. Several studies have shown self-dilatation to be a safe and effective treatment modality in motivated human patients, resulting in positive emotional, social, and financial impacts assessed by quality of life scores.[15–17]

The purpose of our study was to determine if the B-Tube technique could be easily performed, well tolerated by the animals, and effective in maintaining dilatation of a BES after removal of the device. Our hypothesis was that the use of the B-Tube would be an effective, dual-procedure (placement and removal) alternative to repeat balloon dilatation procedures for the treatment of BES in dogs and cats.

TABLE 1 Table demonstrating data stratification for analysis of equivalent modified dysphagia score (MDS) where available, from currently published relevant literature

Study	Number of cases	Equivalent dysphagia score of 0/4	Equivalent dysphagia score of 1–2/4	Equivalent dysphagia score of 3/4	Equivalent dysphagia score of 4/4	Reported success rate	Cases with dysphagia 2/4 or better	Median treatments	Mean treatments	Mortality rate
Harai et al (1995)	13	3/13 (23.1%)	7/13 (53.8%)	1/13 (7.7%)	1/13 (7.7%)	11/13 (84.6%)	10/13 (76.9%)	4	4.2 (1–8)	3/13 (23.1%)
Bissett et al (2009)	28	6/28 (21.4%)	14/28 (50%)	5/28 (17.9%)	3/28 (10.7%)	20/28 (71.4%)	20/28 (71.4%)	Dogs: 3; Cats 4.5	4.5 (1–10)	5/28 (17.9%)
Leijb et al (2001)	25	3/25 (12.0%)	13/25 (52.0%)	6/25 (24.0%)	N/A	22/25 (88.0%)	16/25 (64.0%)	2	2.2 (1–5)	3/25 (12.0%)
Adamama-Moraitou et al (2002)	20	Reported as cases that did not regurgitate dry food −14/20 (70.0%)		-	-	14/20 (70.0%)	14/20 (70.0%)	2	2.4 (1–4)	6/20 (30.0%)
Melendez et al (2002)	23	4/23 (17.4%)	10/23 (43.5%)	3/23 (13.0%)	2/23 (8.7%)	14/19 (73.7%)[a]	14/23 (60.9%)	Not reported	3 (1–9)	4/23 (17.4%)
Results of our study	12	8/12 (66.7%)	3/12 (25%)	0 (0.0%)	1/12 (8.3%)	11/12 (91.7%)	11/12 (91.7%)	2	2.2 (1–3)	1/12 (8.3%)

A MDS of 0 is given to animals able to eat a normal diet with no dysphagia. A MDS of 1 is given to animals able to swallow some solid foods (kibble or canned food). A MDS of 2 is given to animals able to swallow only semi-solid foods (gruel). A MDS of 3 is given to animals able to swallow liquids only. A MDS of 4 is given to animals unable to swallow anything including saliva; total dysphagia.

[a]Data excluded deceased animals.

2 | MATERIALS AND METHODS

2.1 | Case selection

A prospective study was designed to recruit, in a continuous fashion, dogs and cats with confirmed esophageal strictures. Inclusion criteria required confirmation of an esophageal stricture by esophagoscopy; no comorbidities precluding general anesthesia; signed informed consent; ability of owners to perform dilatation procedures at home; complete history with modified dysphagia score (MDS) and number of previous dilatations; and subsequent follow-up information for living animals. These lesions are not routinely biopsied when case history is consistent with BES and therefore histopathology was not an inclusion criterion for the study.

2.2 | Description and function the B-Tube

The B-Tube is a noncompliant esophageal balloon dilatation device mounted on a commercially available and commonly used esophagostomy tube (E-tube; Figure 1). An additional external compliant polyurethane balloon captures and constricts the inner noncompliant balloon to maintain a low-profile device when deflated. Once a BES has been diagnosed and balloon-dilated under fluoroscopic and endoscopic guidance, the B-Tube is placed similarly to a standard esophagostomy tube (E-tube) with some technical modifications.

2.3 | Placement of B-Tube

Animals were placed under general anesthesia and positioned on a fluoroscopic table in right lateral recumbency for esophagoscopy. Diagnostic esophagoscopy was performed at the time of B-Tube placement to confirm the presence of the stricture(s). Esophageal diameter measurements were performed using a marker catheter, iodinated contrast (Omnipaque 240, GE Healthcare Inc., Princeton, New Jersey), and fluoroscopy while insufflating the esophagus with air to determine the maximal esophageal diameter (Figure 2). The location, length, and minimal diameter of the esophageal stricture(s) was (were) recorded. Pre-dilatation was performed with an appropriately sized standard esophageal balloon dilatation catheter (Eliminator PET Balloon Dilators, ConMed Endoscopic Technologies) matched to the maximal esophageal diameter and filled with 50:50 iodinated contrast (Omnipaque 240, GE Healthcare Inc., Princeton, New Jersey) and saline using a digiflator (EndoTek Big 60, Merit Medical Systems, Inc., South Jordan, Utah). After confirming stricture effacement, the B-Tube was placed according to manufacturer recommendations (Figure 3) and secured in the left lateral neck, as is standard for E-tubes. Fluoroscopy was used to demonstrate appropriate placement of the B-Tube across the stricture, without interfering with the upper (UES) or lower (LES) esophageal sphincter when possible. For distal strictures, the B-Tube was placed across the LES, and for very proximal strictures, the B-Tube was placed as a pharyngostomy tube to ensure the balloon extended rostral to the cervically located BES. Once secured, the B-Tube was inflated with air using a digiflator under fluoroscopic monitoring to ensure the dilated balloon remained across the previous stricture site by at least 5 cm when possible. The volume of air used to develop uniform balloon

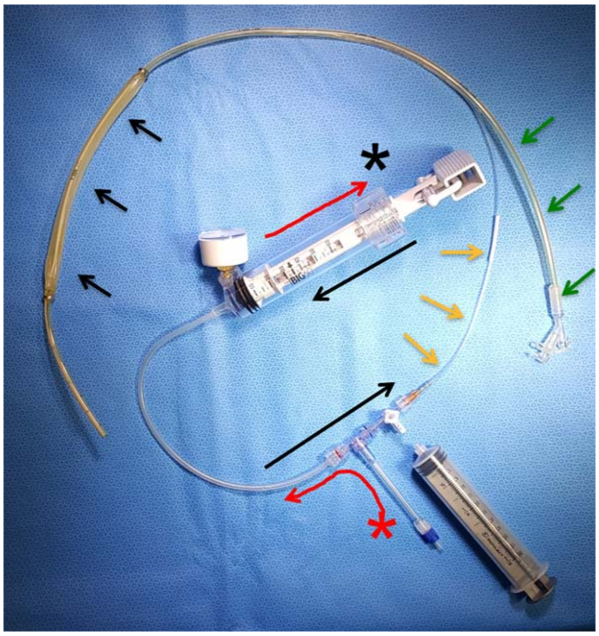

FIGURE 1 Balloon dilatation esophagostomy tube components in detail and set-up for inflation. Components include the balloons (short black arrows), E-tube (green arrows), inflation tubing (yellow arrows), centesis valve (red asterisk), Endotek Big 60 inflation syringe (black asterisk), and direction of airflow during inflation (red arrows show direction of airflow coming into syringe, and black arrows show airflow directed into balloon)

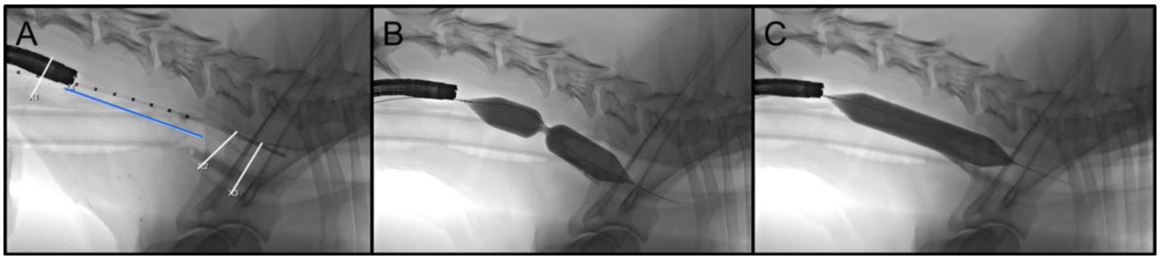

FIGURE 2 Lateral cervical fluoroscopic images of Dog 9 during balloon dilatation procedure. (A) X1, X2, and X3 (white lines) are measurements of esophageal diameter. X4 (blue line) demarcates the esophagus through which the balloon dilatation esophagostomy tube must be centered. (B) Placement of the balloon dilatation catheter across the esophageal stricture with partial inflation demonstrating remaining non-effaced stricture. (C) Effacement of the esophageal stricture

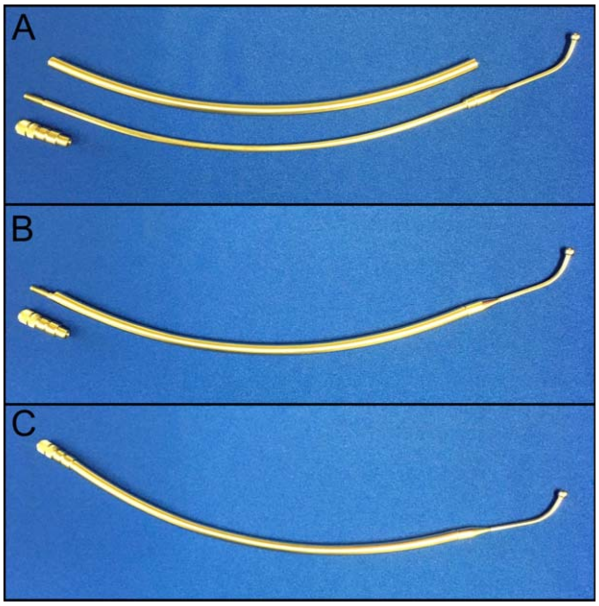

FIGURE 3 Tube passer designed to facilitate atraumatic placement of the balloon dilatation esophagostomy tube (B-tube). The B-tube is a large E-tube, and passing it through the hollow cannula of the tube passer reduces tissue trauma. (A) Disassembled tube passer with hollow sheath, blunt inner trocar, and screw fastener. (B) Partially assembled tube passer. (C) Fully assembled tube passer

dilatation across the entire length of the B-Tube was recorded for use in individualized inflation volumes, while ensuring not to exceed maximal recommended balloon inflation pressures. Fluoroscopy and thoracic radiography were performed to document the final position of the B-Tube (Figure 4).

Postoperatively, all animals were treated with medications including, but not limited to, omeprazole (1 mg/kg PO q12h; Prilosec, Proctor and Gamble, Cincinnati, Ohio), tramadol (2–4 mg/kg PO q8h; Ultram, Ortho-McNeil-Janssen Pharmaceuticals, Inc., Titusville, New Jersey), antiemetics (ondansetron, 0.5 mg/kg PO q24h; Zofran, GlaxoSmithKline, Philadelphia, Pennsylvania) or maropitant citrate (2 mg/kg PO q24h; Cerenia, Zoetis Inc., Kalamazoo, Michigan), and sucralfate (0.5-1g PO q6-8h; Carafate, Aptalis Pharma US, Inc., Bridgewater, New Jersey). Tramadol was prescribed for 5 days, whereas all other medications were prescribed for 4 weeks. All animals were fed through the B-Tube feeding tube the first night, then a high-calorie gruel or wet food (Maximum Calorie, Eukanuba, Mason, Ohio, a/d, Hill's Science Diet, Topeka, Kansas) PO until discharge.

A single lateral cervical and thoracic radiograph was obtained the next morning to ensure the B-tube position was unchanged. The first B-Tube air inflation then was performed with owner observation (Figure 1). Owners were instructed to perform dilatations using the same volume of air twice daily for the next 6 weeks. Oral feedings consisting of liquid gruel were commenced that day, and gradually transitioned to firmer food at the owners' discretion over the next 1–2 weeks.

2.4 | Complications

Complications were defined as "minor" if successfully managed medically, and "major" if another anesthetic intervention was necessary.

2.5 | Follow-up information

Reevaluations were performed at 3–7 days postoperatively (ie, examine tube insertion site), 6-weeks postoperatively (ie, general anesthesia, esophagoscopy, and B-Tube removal), and 12-weeks postoperatively (ie, esophagoscopy if MDS was not improved; Figure 5). Follow-up information was collected for a minimum of 6 months for monitoring MDS and other clinical signs.

2.6 | Statistical analysis

Baseline descriptive statistics are presented as mean and standard deviation for normally distributed variables whereas nonnormally distributed variables are presented as median and range. Between groups, analyses of baseline variables were performed using analysis of variance (ANOVA) or the Wilcoxon test as appropriate for the data distribution. The normality of the error residuals was analyzed by the Kolmogorov-Smirnoff test for descriptive and multivariate models. Dependent variables were modeled separately in a mixed model repeated measures ANOVA. Analysis for proportions of categorical variables was performed using Chi-Square analysis or Fisher's exact test where appropriate. All analyses were considered significant if $P < .05$

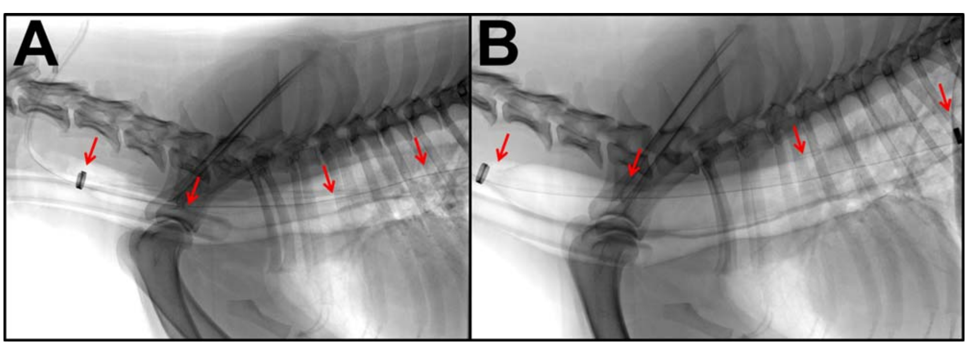

FIGURE 4 Lateral cervical radiographic images of Dog 7 with a deflated balloon dilatation esophagostomy tube (B-tube) (image A) and inflated B-tube (image B) in position. The first and last arrows indicate radio-opaque markers at the ends of the balloon, while the remainder of the arrows indicate the outline of the inflated balloon

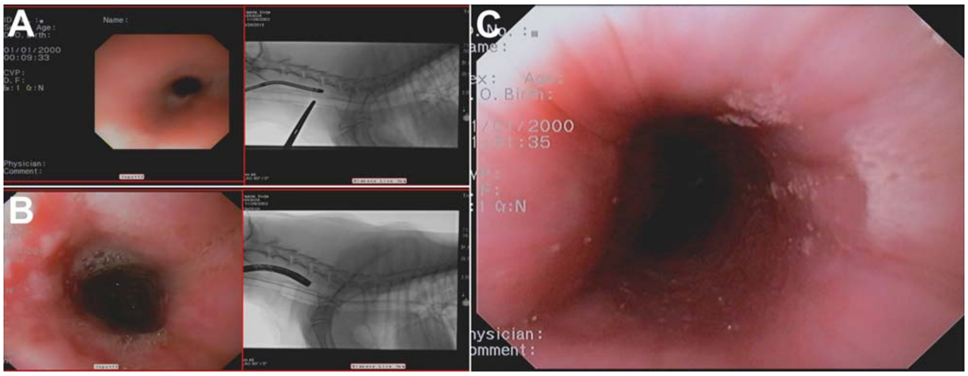

FIGURE 5 Fluoroscopic and endoscopic image example from a dog with a single esophageal stricture (Dog 7). (A) Pre-balloon dilatation. (B) Tube removal at ~6 weeks. (C) Endoscopy performed 6-weeks post tube removal (~12 weeks post balloon dilatation esophagostomy tube placement)

and were carried out using a commercially available statistical software (SAS 9.4, SAS Institute Inc., Cary, North Carolina).

3 | RESULTS

Nine dogs and 3 cats met the inclusion criteria and were enrolled in the study, including 8 spayed female dogs, 1 intact male dog, and 3 spayed female cats. No animals failed the inclusion criteria during our study. Animals had a mean age of 4.6 ± 4.2 years. Breeds represented included 2 Labrador Retrievers, 2 mixed breed dogs, and 2 domestic short hair cats each, and 1 of each of the following: German Short-Haired Pointer, Chihuahua, Dachshund, Doberman Pinscher, Flat-Coated Retriever, and a Maine Coon Cat. Two of 3 cats and 7/9 dogs developed clinical signs of regurgitation and esophageal strictures after general anesthesia. One dog developed signs after severe vomiting episodes requiring hospitalization, and 1 dog after commencement of hydroxyurea therapy, and 1 cat after doxycycline therapy.

Clinical signs developed within 1 week of these episodes for all animals, and included regurgitation, weight loss, vomiting, and owner perception of malaise. After onset of clinical signs, all animals were initially managed medically with H-2 receptor antagonists, proton pump inhibitor drugs, antiemetics or some combination of these with no relief of clinical signs. Data including location and number of strictures, number of esophageal dilatation procedures performed before B-Tube placement, and details of B-Tube size and use is available (see Supporting Information Table S1).

All dogs and cats were discharged from the hospital 1 day after the procedure. In all cases, inflations resulted in swallowing and gagging, but resolved immediately after deflation of the balloon. Minor complications encountered in 7/12 (58.3%) cases included regurgitation (3/12), B-tube exit site skin infection (2/12), and vomiting (2/12). Cat 1 regurgitated the B-Tube twice when it backed into the oropharynx, but it was easily repositioned without sedation using manual manipulation. These smaller 10 Fr tubes subsequently were redesigned to be stiffer (14 Fr) to resist folding or kinking. Dog 4 regurgitated once during 43 days of B-Tube use. Dog 5 and Cat 2 developed tube exit site skin infections that were treated with a course of Cefovecin (8 mg/kg SQ; Convenia, Zoetis Inc., Kalamazoo, Michigan) and Clavamox (15 mg/kg PO q12h; Clavamox, Zoetis Inc., Kalamazoo, Michigan), respectively, resolving the infections. Dog 1 dislodged the B-Tube, resulting in the distal tip exiting the mouth, during a vomiting episode after 16 days of use. Esophagoscopy was performed by the referring veterinarian revealing an improved stricture with minimal luminal compromise, and therefore the B-tube was not replaced. The MDS was unchanged at 3/4 at the time of B-Tube removal, but continued to improve after removal with a final MDS of 1/4.

Major complications were encountered in 2 animals (2/12; 16.7%). Dog 3 experienced frequent regurgitation episodes, and a major complication, requiring an anesthetic procedure at 41 days post-placement to replace the B-Tube because of a broken inflation port that restricted balloon inflation. At that time, esophagoscopy disclosed persistent, marked esophageal inflammation consistent with persistent regurgitation. This dog had comorbidities including polycythemia vera, seizures, and suspected inflammatory bowel disease thought to be responsible for clinical signs. Because of persistent regurgitation, and comorbidities, the B-Tube tube was removed after 75 days of use and repeat esophagoscopy was not performed. This dog continued to deteriorate and died 88 days after initial treatment. Upon repeat esophagoscopy in Dog 8, the stricture had improved from a 9 mm stricture to approximately 20 mm in diameter, however, it was noted that during complete inflation, the balloon slipped below the ideal position of the stricture because of the proximal location of the lesion. The B-tube was removed and a larger B-tube was placed for an additional 49 days, and stricture resolution was noted during esophagoscopy upon final removal. Dog 8 also vomited intermittently during B-Tube use, and had a final MDS of 1/4.

The B-Tube had to be placed across the LES or UES in 8/12 animals, however this did not significantly ($P = .09$) result in development of nausea, vomiting, or regurgitation. Dog 1 was among these dogs, and was the only animal from which the B-tube was removed prematurely because of vomiting and subsequent tube malpositioning.

A summary of MDS before treatment, after treatment, and at final follow-up, as well as findings at repeat esophagoscopy and weight changes from initiation to completion of the study is available (see

Supporting Information Table 2). The mean duration of B-Tube placement was 41 days (range, 16–75 days). Dog 9 required B-Tube repositioning for treatment of the most proximal of 3 different strictures which was recorded as a single case, but not as a major complication. The B-Tube could only be positioned over the distal 2 strictures initially for a duration of 40 days because of insufficient balloon length to span all 3 strictures simultaneously. After resolution of the 2 distal strictures, the B-Tube was repositioned cranially to treat the proximal stricture for an additional 37 days, achieving a final MDS of 0/4.

At final follow-up examination (median, 472 days; range, 358–1736 days), 8/12 cases (66.7%) had an MDS of 0/4, 2/12 cases (16.7%) an MDS of 1/4 and 1 case displayed an MDS of 2/4. The other case (1/12; Dog 3) died, 75 days after B-Tube placement. In this case, clinical suspicion was that death was caused by comorbidities. Additionally, regular inflation procedures were not confirmed to have been performed by the owner because of the dog's medical conditions and further dysphagia outcomes could not be determined because of lack of client response; no postmortem examination was performed. Additionally, all animals had unchanged or improved MDS between B-Tube removal and final follow-up, except for Dog 2 (3/4 before treatment, 1/4 at removal, 2/4 at final follow-up). A mean increase of 10.1% (−3.0 to 28.5%) in body weight was also documented over the duration of the study period at final follow up. Dogs and cats had a mean weight increase of 10.9% and 7.5%, respectively.

Final posttreatment MDS was significantly different from pretreatment MDS ($P < .01$). Posttreatment MDS was not significantly affected by stricture cause, number and location of strictures, number of previous dilatations, breed, age, sex, weight, tube presence across the UES or LES, pre-procedure MDS scores, or duration of B-Tube use.

4 | DISCUSSION

Our results suggest that treatment of esophageal strictures by use of the novel indwelling B-Tube technique appears safe and can be effective in both dogs and cats. The primarily single esophageal strictures (9/12) identified in our study are consistent with those previously reported.[2–4,12,13] The cause of strictures in our study and currently available literature were similar.[1–4,9,12] Although MDS have not been used in currently available literature, descriptive terminology identical to that used to create the scoring system are reported. Where described, as indicated by Table 1, the scores are applied verbatim. In the literature, no distinction is routinely made between canned food or gruel consistencies, and admixed with these cases are animals that regurgitated occasionally (less than once weekly).[2–4,13] Therefore, these cases were classified with the MDS of 1–2/4, and given a combined score of 1.5/4 for calculation of mean overall score per study.

As part of the study protocol, general anesthesia was performed at least twice for treatment of each animal, once for initial esophagoscopy and B-Tube placement, and once for repeat esophagoscopy and B-Tube removal. In some animals, general anesthesia was not necessary for tube removal, but performed as part of the study protocol to document the change in the stricture. Some animals may not need a second anesthetic episode if the tube can be easily removed. Fluoroscopic guidance was utilized in our study (Figure 2) in conjunction with esophagoscopy because we believe that complete stricture effacement often is not completely appreciated by esophagoscopy alone. This combination of techniques may have contributed to the improved proportion of cases achieving complete dysphagia resolution.[2–4,12] In addition, fluoroscopic measurements of an air-distended esophagus were used to choose ultimate balloon dilatation diameter. This approach may be more aggressive than that used in previous studies, however means of determination of maximal balloon dilatation diameters used often is not described in other reports.[3,4]

Successful management of the B-Tube requires the same commitment and learning as for a conventional E-tube. Live demonstration by the clinician, and observation by the owners during inflation the first time is essential to the success of this procedure. Most commonly, owners needed assurance that although inflations may cause gagging, it would cease as soon as the balloon was deflated. Owners had to be instructed to inflate the balloon based on the individualized volume, followed by immediate deflation. There is no need to keep the balloon dilated before deflation, which increases the likelihood of discomfort and gagging. As with E-tube care, clients are encouraged to feed PO progressively thickened gruels, canned food, and dry kibble over time to encourage esophageal use and function.

The design and protocol of the B-Tube is such that the initial stricture dilatation is performed under general anesthesia; this is reportedly an uncomfortable process in humans.[18] The indwelling B-Tube is meant to maintain dilatation of a previously effaced stricture rather than to tear it anew each time. This seems temporarily uncomfortable but the discomfort passes immediately upon deflation. Analgesics were not utilized routinely and not considered necessary in most cases. In addition, the use of air instead of liquid allowed rapid tube inflation and deflation. The procedure would have taken much longer had fluid been used because of the associated viscosity. Once the stricture has been effaced, air is sufficient to maintain dilatation and prevent the stricture from reforming.

Dog 3 was unique in that substantial comorbidities present, compared to the other cases where the underlying causes of the BES had since resolved or passed. Dog 3 was the only case to fail treatment, ultimately dying, likely because of severe comorbidities including polycythemia vera, seizures, and suspected underlying gastrointestinal disease. This dog also was classified as experiencing a major complication as a consequence of the need for an unplanned anesthetic procedure to replace a broken B-Tube component. A postmortem examination was not performed, and therefore a definitive diagnosis was not available. Dog 1 removed the B-Tube prematurely during a vomiting episode 16 days after placement, possibly because of the tube entering the stomach secondary to a very distal stricture necessitating the placement of the B-Tube across the LES. This dog's final MDS was 1/4 (pretreatment score, 3/4) after removal. Given that esophagoscopy identified only mild residual esophageal narrowing, a decision was made by the referring veterinarian not to replace the tube at that time. This case may have had a more successful outcome if the B-Tube was replaced and maintained for the 6-week target period. Duration of treatment was not statistically significant in our study. Additionally, the presence of the B-Tube across the LES may be a cause of nausea and result in episodes of vomiting or regurgitation. Surprisingly, placement across neither the LES nor UES resulted in repeatable occurrence of more severe clinical signs.

Similar to Dog 3, Dogs 1, 4, and 8 also had very mild persistent strictures at the time of the repeat esophagoscopy that we assumed would not result in persistent clinical signs. Resultant MDS at final follow up were 1/4, 2/4, and 1/4, respectively. All dogs and cats with normal findings during repeat esophagoscopy eventually recovered completely with no evidence of dysphagia. Additionally, Dog 4 was noted to have widening of the LES and displayed an MDS of 1/4 at the time of B-Tube removal. At final follow-up, an MDS of 2/4 was recorded. Lower esophageal sphincter incompetence in this dog may have resulted in ongoing chemical injury from gastric reflux, leading to formation of another stricture, and recurrence of clinical signs. Alternatively, this finding may have been observed only under anesthesia and may not have persisted. Conversely, Cat 1 had a persistent mild smooth stricture with a diameter of 10 mm but eventually achieved an MDS of 0/4. Given that all cases with complete stricture resolution ultimately achieved resolution of clinical signs, our results suggest that complete, or near complete (as for Cat 1) stricture resolution may be necessary for an ideal outcome, but further studies are needed for appropriate interpretation.

Twice daily B-Tube inflations presumably cause microtrauma to the previously dilated strictures, preventing fibrosis with contraction and subsequent stricture recurrence. After full thickness esophageal injuries, edema of the subepithelial components of the mucosa and submucosa may persist for up to 2 weeks. With mucosal defects, healing is achieved within 3 days if direct mucosal apposition is accomplished.[19,20] However, this is unlikely after stricture effacement. The 6-week treatment duration was a goal established to allow for sufficient tissue repair, minimizing the risk of stricture reformation after B-Tube removal. Three dogs continued to show clinical improvement after B-Tube removal, with improved MDS at final follow-up. This observation was thought to be associated with the presence of a relatively large profile B-Tube within the esophageal lumen preventing larger foods from passing easily. It is also likely that clinically relevant esophageal inflammation remained even toward the end of the 6-week period, caused by the physical presence of the B-Tube. This often was observed at time of tube removal. The 6-month follow-up period in our study resulted in improvement in all strictures, except for the stricture in Dog 3. Further studies will be required to determine the ideal treatment duration for less severe strictures, and if shorter treatment times would result in similar success rates.

Eleven of 12 animals (91.7%) had improved MDS at the end of the follow-up period. When compared to recent studies evaluating success rates after treatment of esophageal strictures by balloon dilatation or bougienage, our study had an equal or increased proportion of cases that ultimately demonstrated no dysphagia, with fewer anesthetic episodes required to reach these results and often with less mortality as well.[2–4,12,13] One of 12 animals (8.3%) experienced a major complication, requiring replacement of the B-Tube under anesthesia. This same animal did not survive to the end of the follow-up period. The mortality rate in our study is lower than the 12.0–30.0% currently reported in the literature.[2–4,12,13] The comparison is demonstrated in Table 1.

The limitations of our study are small sample size and lack of a control group. Future controlled, randomized studies with a larger sample size of both species are required to more accurately evaluate clinical responses.

Recently, an investigation using iodine-125 pre-loaded esophageal stents on Beagles also has been reported, effectively decreasing esophageal fibroblast proliferation and benign restenosis, but this remains an experimental treatment.[21] Stents still may play a role in refractory BES not amenable to traditional dilatation or B-Tube therapies, particularly strictures too proximal for effective B-tube placement, even when used with pharyngostomy access.

The B-Tube required approximately 2 general anesthesia episodes per stricture in our study protocol, and initial results suggest equivalent or improved outcomes compared to those previously reported for BES in dogs and cats may be possible. This is similar to, or fewer than, the mean number of general anesthetic events (range, 2.2–4.5 treatments) needed in previous studies.[2–4,12,13] In routine cases, the B-Tube may be removed without general anesthesia.

The results of our pilot study suggest that the indwelling B-Tube may be an effective alternative to repeated balloon dilatation procedures for the treatment of BES in dogs and cats. Although further studies are necessary to determine the ideal duration of treatment, this procedure in its current form may offer a cost effective alternative and may be considered at minimum an equally successful technique for treatment of dogs or cats with esophageal strictures.

CONFLICT OF INTEREST DECLARATION

Dr. Weisse is a consultant for Mila International.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

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

This study was approved by the Animal Medical Center IACUC.

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REFERENCES

[1] Wilson DV, Walshaw R. Postanesthetic esophageal dysfunction in 13 Dogs. *J Am Anim Hosp Assoc*. 2004;40:455–460.

[2] Bissett SA, Davis J, Subler K, et al. Risk factors and outcome of bougienage for treatment of benign esophageal strictures in dogs and cats: 28 cases (1995–2004). *J Am Vet Med Assoc.* 2009;235:844–850.

[3] Leib MS, Dinnel H, Ward DL, et al. Endoscopic balloon dilation of benign esophageal strictures in dogs and cats. *J Vet Intern Med.* 2001;15:547–552.

[4] Harai BH, Johnson SE, Sherding RG. Endoscopically guided balloon dilatation of benign esophageal strictures in 6 cats and 7 dogs. *J Vet Intern Med*. 1995;9:332–335.

[5] Leib MS, Sartor LL. Esophageal foreign body obstruction caused by a dental chew treat in 31 dogs (2000–2006). *J Am Vet Med Assoc*. 2008;232:1021–1025.

[6] Gianella P, Pfammatter NS, Burgener IA. Oesophageal and gastric endoscopic foreign body removal: complications and follow-up of 102 dogs. *J Small Anim Pract*. 2009;50:649–654.

[7] Fox E, Lee K, Lamb CR, et al. Congenital oesophageal stricture in a Japanese shiba inu. *J Small Anim Pract*. 2007;48:709–712.

[8] Beatty J, Swift N, Foster D, Barrs V. Suspected clindamycin-associated oesophageal injury in cats: five cases. *J Feline Med Surg*. 2006;8:412–419.

[9] German A, Cannon M, Dye C, et al. Oesophageal strictures in cats associated with doxycycline therapy. *J Feline Med Surg*. 2005;7:33–41.

[10] Lam N, Weisse C, Berent A, et al. Esophageal stenting for treatment of refractory benign esophageal strictures in dogs. *J Vet Intern Med*. 2013;27:1064–1070.

[11] Glanemann B, Hildebrandt N, Schneider MA, et al. Recurrent single oesophageal stricture treated with a self-expanding stent in a cat. *J Feline Med Surg*. 2008;10:505–509.

[12] Adamama-Moraitou KK, Rallis TS, Prassinos NN, Galatos AD. Benign esophageal stricture in the dog and cat: a retrospective study of 20 cases. *Can J Vet Res*. 2002;66:55–59.

[13] Melendez LD, Twedt DC, Weyrauch EA, Willard MD. Conservative therapy using balloon dilation for intramural, inflammatory esophageal strictures in dogs and cats: a retrospective study of 23 cases (1987–1997). *Eur J Comp Gastroenterol*. 1998;3:31–36.

[14] Pavletic MM. Reconstructive esophageal surgery in the dog: a literature review and case report. *J Am Anim Hosp Assoc*. 1981;17:435.

[15] Zehetner J, DeMeester SR, Ayazi S, Demeester TR. Home self-dilatation for esophageal strictures. *Dis Esophagus*. 2014;27:1–4.

[16] Davis SJ, Zhao L, Chang AC, Orringer MB. Refractory cervical esophagogastric anastomotic strictures: management and outcomes. *J Thorac Cardiovasc*. 2011;141:444–448.

[17] Dzeletovic I, Fleischer DE, Crowell MD, et al. Self-dilation as a treatment for resistant, benign esophageal strictures. *Dig Dis Sci*. 2013;58:3218–3223.

[18] Barish CF, Castell DO, Richter JE. Graded esophageal balloon distention. A new provocative test for noncardiac chest pain. *Dig Dis Sci*. 1986;31:1292–1298.

[19] Clay RP. Wound healing: biochemical and clinical aspects. In: Cohen I, Diegelmann R, Lindbald W, eds. Wound Healing: Biochemical and Clinical Aspects. Philadelphia, PA: WB Saunders; 1992:932–933.

[20] Graham M, Blomquist P, Zederfeldt B. The alimentary canal. In: Cohen I, Diegelmann R, Lindbald W, eds. Wound Healing: Biochemical and Clinical Aspects. Philadelphia, PA: WB Saunders; 1992:433.

[21] Gan Z, Jing J, Zhu G, et al. Preventive effects of ^{125}I seeds on benign restenosis following esophageal stent implantation in a dog model. *Mol Med Rep*. 2015;11:3382–3390.

SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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