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CLINICAL RESEARCH

Use of the Endo GIA™ stapler for lung lobectomy in dogs and cats undergoing open thoracic procedures (intercostal, transdiaphragmatic thoracotomy or median sternotomy): A retrospective study of 46 lung lobectomies

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Abstract

Objective: To describe Endo GIA stapler use in open approach lung lobectomies. Endo GIA stapler use for open approach lung lobectomies has been validated in cadaveric studies; however, current veterinary literature lacks in vivo studies.

Study design: Retrospective study.

Sample population: A total of 33 dogs and four cats (37 cases, 46 lung lobectomies).

Methods: Records from November 2019 to September 2024 at a single institution were reviewed. Dogs and cats that underwent lung lobectomy via thoracotomy (intercostal, transdiaphragmatic) or median sternotomy using Endo GIA staplers were included. Pre-, intra-, and postoperative data were collected. Complications were assessed using the Cook Complication Grading System. Complication rate was analyzed to demonstrate use of Endo GIA staplers in open thoracic procedures. Cases included had a 14-day follow-up at minimum or at death.

Results: A total of 46 lung lobectomies (37 cases) were performed using an Endo GIA stapler via open thoracic procedures. No intraoperative complications were noted in 38/46 (82.6%) lung lobectomies. Minor intraoperative complications occurred in 8/46 (17.4%) lobectomies. No major complications occurred. Catastrophic complications occurred in 4/37 (10.8%) cases (4/46 [8.7%] lung lobectomies) postoperatively, likely due to comorbidities. Cases that reached 14-day follow-up, despite one minor postoperative complication of seroma formation, had no complications (32/33, 97%).

Conclusion: Endo GIA stapler use for open approach lung lobectomies proved to be a valid procedure with minimal complications. The unique properties of the Endo GIA stapler offered an alternative to traditionally used staplers for lung lobectomy.

Clinical significance: Endo GIA staplers can be used for open approach lung lobectomy as a beneficial alternative with minimal complications.

1 | INTRODUCTION

Traditional lung lobectomy techniques in veterinary patients such as hand ligation of hilar vessels and bronchi are largely being replaced due to recent advances in stapling technology.[1–4] Thoracoabdominal (TA) 30 or TA 55 staplers are the most commonly reported staplers utilized for open thoracic lung lobectomy procedures in dogs and cats.[5] The Endo GIA™ stapler (Medtronic, Minneapolis, Minnesota), the endoscopic version of the GIA™ stapler (Medtronic), is historically used and designed for minimally-invasive thoracoscopic procedures.[1,3,5,6] Use of the Endo GIA has not been described in clinical settings for in vivo open thoracic procedures, but such application has been reported in cadaveric studies.[3] The standard GIA stapler does not offer articulation, rotation, or a long handle for deep cavities, and thus the authors prefer the Endo GIA.

Open surgical approaches to the thorax in dogs and cats include intercostal or transdiaphragmatic thoracotomy and median sternotomy.[7] The TA stapler contains a tissue-retaining pin, allowing the stapler to maintain tissue without compression.[8] The white staple cartridges (V3) are only available in 30 mm stapler shaft lengths,[1] which can limit the amount of pulmonary tissue that the stapler can span. The white cartridges fire three staggered rows of staples with closed heights of 1.0 mm, whereas blue cartridges fire two staggered rows of staples with closed heights of 1.5 mm. After the stapler is deployed, the tissue must be manually transected by the surgeon.[1] The TA stapler has a fixed U-shaped anvil that is not able to articulate (Figure 1). Conversely, the Endo GIA stapler offers five directions of articulation, can be axially rotated, and has a simultaneous staple/cut function, offering both optimal maneuverability and safety in tight cavities. Articulation and rotation include up to 45° in both left and right directions as well as a 360° rotation, respectively (Figures 2 and 3). Studies that evaluated the use of Endo GIA staplers in thoracoscopic procedures contained cases that converted to an open approach, in which the TA stapler or hand ligation techniques were then employed, despite having access to the Endo GIA stapler.[6,9]

There are notable differences between the commonly used TA stapler and the Endo GIA stapler, including cartridge specifications (number of staple rows, mode of tissue transection, stapler length, staple height). All Endo GIA stapler cartridge sizes, except the Extra Thin/Vascular (gray) cartridge, deploy triple-staggered and stepped staples on either side of a blade that simultaneously transects tissue. The Endo GIA stapler cartridges also come in a variety of lengths (30, 45, and 60 mm) and staple heights to span a wide range of tissues. The initial model of Endo GIA staplers consisted of the Universal stapler, however, Tri-Staple technology was later developed to allow for better stapler performance and a wider range of use.[10] Differences include stepped cartridges with height-progressive staple rows and higher clamping force.[11] This allows for use over a broader range of tissues due to increased burst strength and optimal tissue compression.[10] The Endo GIA Tri-Staple 2.0 device (45 and 60 mm length of either Vascular/Medium [tan] or Medium/Thick [purple]) correlates to the commonly used TA staplers for lung lobectomy. The Endo GIA Tri-Staple 2.0 Vascular/Medium (tan) stapler contains staples of 3.0, 2.5, and 2.0 mm in height from outer to inner row

FIGURE 1 Thoracoabdominal (TA) stapler (top) and the Endo GIA stapler (bottom) loaded with 30 mm V3 and Endo GIA Tri-Staple 2.0 45 mm Vascular/Medium (tan) cartridges, respectively.

FIGURE 2 Articulation of the Endo GIA stapler includes up to 45° in both left and right directions.

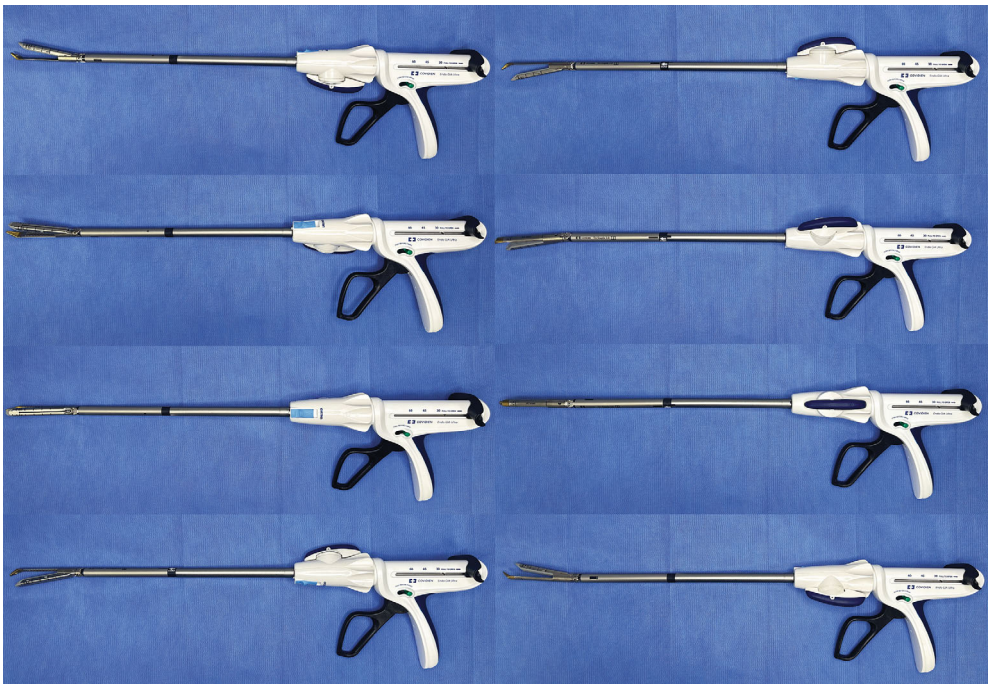

FIGURE 3 The image shows 360° axial rotation of the Endo GIA stapler in approximately 45° increments.

and close to staple heights of 1.25, 1.0, and 0.75 mm, respectively.[3,12,13] The Endo GIA Tri-Staple 2.0 Medium/Thick (purple) stapler contains staple heights of 4.0, 3.5, and 3.0 mm which respectively close to heights of 1.75, 1.5, and 1.25 mm.[12,13] The smallest Endo GIA stapler option is the Endo GIA Tri-Staple 2.0 Extra Thin/Vascular (gray) which is the only Endo GIA stapler with non-stepped staples, all of which are 2.0 mm in height and compress to 0.75 mm.[3,12]

The use of Endo GIA staplers for lung lobectomy via open thoracic procedures has been validated in cadaveric studies.[3,14] Current veterinary literature lacks reported in vivo clinical studies that demonstrate the use of the Endo GIA stapler in open thoracic procedures. The aim of this retrospective study was to describe Endo GIA stapler use for patients undergoing an open thoracic lung lobectomy and to highlight its high success rate and various unique qualities, such as simultaneous staple/cut function, articulation and rotational movement, as well as deployment of two sets of triple-staggered and stepped staple rows.

2 | MATERIALS AND METHODS

2.1 | Case inclusion

Medical records from November 2019 to September 2024 at a single institution were reviewed and included dogs and cats that had a lung lobectomy via thoracotomy (intercostal, transdiaphragmatic) or median sternotomy using an Endo GIA stapler. The Endo GIA Universal stapler was used in earlier cases. Use of the Endo GIA Tri-Staple device predominated previous stapling technology once available, and the Universal was used less frequently. Cases that included hand ligation or alternative stapler use for lung lobectomy were excluded. Cases included in surgery time analysis consisted of procedures in which lung lobectomy was the main procedure performed. Postoperative data collection included cases that had accurate time points of discharge, thoracostomy tube removal, and follow-up information documented in the medical record. All cases that were discharged had a minimum of a 14-day follow-up recorded. Follow-up was defined as a 14-day minimum or at death.

2.2 | Data collection

Pre-, intra-, and postoperative data were collected, and procedural complications were assessed using the Cook Classification System.[15] Preoperative data included species, age (years), sex, neuter status, breed, weight (kilograms), and reason for surgery. Intraoperative data included surgical approach, lung lobe location, partial versus total lung lobectomy, stapler characteristics (length and size), surgical time, additional procedures, results of saline bubble leak test, and thoracostomy tube placement. Postoperative data included complications according to the Cook Classification System, histopathology and margin assessment if applicable, follow-up information, duration of

thoracostomy tube (days), and duration of hospitalization (days). Complication rates were examined to demonstrate the use of the Endo GIA stapler during open thoracic procedures.

Surgical time was recorded and defined as time from first incision to closure. All patients had thoracostomy tubes placed intraoperatively if not already in place preoperatively.

Complications were recorded intraoperatively and in the immediate postoperative period. As per the Cook Classification System, complications were considered minor if they did not require intervention (medical or surgical). Minor intraoperative complications were classified as minor hemorrhage or air leakage which were appropriately addressed intraoperatively. Major complications included those requiring additional medical or surgical treatment. Catastrophic complications included those resulting in permanent dysfunction, death, or leading to euthanasia.[15] The Cook time frame for data collection included the perioperative (pre-, intra-, and postoperative) period which was defined as 0–3 months. In this study, intraoperative complications were analyzed based on total number of lung lobectomies. Postoperative complications were assessed based on number of patients.

2.3 | Procedure

Total lung lobectomies were performed as close to the hilus as possible and partial lobectomies with margins as the surgeon deemed appropriate. All lung lobectomies were performed using a range of Endo GIA Universal staplers (45 mm Endo GIA Universal 2.5 mm [white] and 45 mm Endo GIA Universal 3.5 mm [blue]) as well as Endo GIA Tri-Staple 2.0 (45 mm Extra Thin/Vascular [gray]) and Endo GIA Tri-Staple 2.0 devices (45 and 60 mm length of either Vascular/Medium [tan] or Medium/Thick [purple]) depending on patient size and lung lobectomy technique.

3 | RESULTS

A total of 52 staplers were employed in this study. Stapler type used and their specifications were outlined (Table 1). A total of 10 Endo GIA Universal staplers and 27 Endo GIA Tri-Staple devices were used in this study. Endo GIA staplers that did not have clearly labeled cartridge details in surgery reports accounted for 15 staplers. A total of 46 lung lobectomies (37 cases) were performed using Endo GIA staplers. Approaches consisted of 18 intercostal thoracotomies, 17 median sternotomies, and two transdiaphragmatic thoracotomies. Lung lobectomies were performed at various locations and were total or partial (Table 2). The study population was comprised of 89.2% dogs (33/37) and 10.8% cats (4/37). Of the dog cohort, there were 54.5% male and 45.5% female dogs, 91% of which were neutered. The cats consisted of 25% male and 75% female, all of which were neutered. The median age of dogs and cats was 7 years (4.5 months–15 years, $n = 33$) and 13.5 years (12–14 years, $n = 4$), respectively. The median weight was 25.6 kg (2.25–55.1 kg, $n = 33$) for dogs and 4.3 kg (3.7–5.89 kg, $n = 4$) for cats. The most common canine breed was the Labrador Retriever. The Domestic Shorthair was the most common breed for cats in this study.

Surgical candidacy, based on clinical history, imaging, and diagnosis, was assessed by the attending surgeon. Most cases had advanced imaging performed, with 35/37 cases (94.6%) undergoing computed tomography (CT) scans. The remaining cases had thoracic radiographs (2/37 cases) performed before surgery.

There were no intraoperative complications noted in 38/46 lung lobectomies (82.6%). Minor intraoperative complications occurred in 8/46 lung lobectomies (17.4%), which included intraoperative minor hemorrhage ($n = 2$) and air leakage ($n = 6$). There were two instances in which hemorrhage occurred. The two instances of hemorrhage were not directly related to the stapled lung lobectomy but involved intercostal artery laceration during closure as well as bleeding after tracheobronchial

TABLE 1 Staplers used consisted of Endo GIA Universal ($n = 10$) and Endo GIA Tri-Staple 2.0 ($n = 27$).

Endo GIA Universal		Endo GIA Tri-Staple 2.0	
Type	**Staplers used**	**Type**	**Staplers used**
45 mm Endo GIA Universal (2.5 mm staples [white])	8	Endo GIA Tri-Staple 2.0 45 mm Extra Thin/Vascular (gray)	3
45 mm Endo GIA Universal (3.5 mm staples [blue])	2	Endo GIA Tri-Staple 2.0 45 mm Vascular/Medium (tan)	8
		Endo GIA Tri-Staple 2.0 60 mm Vascular/Medium (tan)	12
		Endo GIA Tri-Staple 2.0 45 mm Medium/Thick (purple)	2
		Endo GIA Tri-Staple 2.0 60 mm Medium/Thick (purple)	2

Note: Unspecified Endo GIA staplers used in the study and not documented in this table include 15 staplers. There are 52 total staplers in this study.

lymph node removal. These cases were resolved with manual pressure and suture placement in one case and absorbable hemostatic gelatin sponge application in the other. The other six minor complications involved minor air leakage, five of which were due to excess parenchyma that was not captured by the stapling device, and one was due to persistent leakage at the staple site. Iatrogenic air leakage was addressed with hemoclips in four instances. Cyanoacrylate glue was used to repair one of the leakages; however, this ultimately tore lung parenchyma due to nearby adherence of structures. A partial lung lobectomy with a second Endo GIA stapler was performed thereafter to completely resolve the issue. The remaining instance of persistent air leakage was not amenable to oversewing of the staple site, so a total lung lobectomy was performed. No major complications were noted in the perioperative complication period. There were four cases out of 37 (10.8%) that incurred catastrophic complications in the postoperative period (Table 3). All catastrophic complications were cardiopulmonary arrests at various time points postoperatively.

Regarding the catastrophic complication population, patient 1 originally went to surgery for a mediastinal mass removal (Table 3). During surgery, iatrogenic lung lobe laceration from thoracostomy tube placement occurred so a lung lobectomy was performed. This patient later succumbed to complications regarding the mediastinal mass resection in which there was phrenic nerve involvement, and thus was unable to extubate and after surgery. Patient 2 arrested in the immediate postoperative period for unknown reasons. Patient 3 arrested three days postoperatively, suspected due to subclinical pneumonia. Patient 4 originally went to surgery for iatrogenic lung lobe laceration due to thoracostomy tube placement for chylothorax. A lung lobectomy was successfully performed. The patient also had a pericardiectomy and unilateral pleural port placement at the time. Due to persistent and large quantities of chylous effusion production postoperatively, it was elected to take the patient back to surgery for a thoracic duct ligation. Patient 4 was not classified as a major complication, as the reason to go back to surgery was secondary to underlying disease rather than the lung lobectomy procedure. The patient ultimately suffered catastrophic complications and was classified as such, as the patient succumbed to their underlying disease.

Cases with no major postoperative complications (32/33, 97%) were reportedly doing well at 14-day follow-up. One minor postoperative complication (seroma) was recorded (1/33, 3%).

The median surgery time was 110 minutes (55–205 min, $n = 27$). Average hospitalization time (days) and thoracostomy tube placement (days) were analyzed.

TABLE 2 Lung lobectomy location and type.

Lung lobectomy location	Location ($n = 46$)	Total lobectomy ($n = 28$)	Partial lobectomy ($n = 18$)
Right cranial	8	5	3
Right middle	9	4	5
Right caudal	6	4	2
Accessory	4	4	0
Left cranial	15	8	7
Left caudal	4	3	1

TABLE 3 Postoperative complications according to the Cook Classification System.

Postoperative complication	Species	Stapler	Comorbidity	Classification	Outcome
Cardiopulmonary arrest-unable to extubate (patient 1)	Canine	Endo GIA Tri-Staple 2.0 45 mm Vascular/Medium (tan)	Mediastinal mass invading phrenic nerve	Catastrophic	Euthanasia
Cardiopulmonary arrest immediate postoperatively (patient 2)	Canine	Endo GIA Universal 2.5 mm (white)	Pulmonary abscess; pyothorax	Catastrophic	Unsuccessful cardiopulmonary resuscitation
Cardiopulmonary arrest 3-days postoperatively (patient 3)	Canine	Endo GIA 45 mm (unspecified)	Suspected subclinical pneumonia	Catastrophic	Unsuccessful cardiopulmonary resuscitation
Cardiopulmonary arrest 5-days postoperatively (patient 4)	Canine	Endo GIA Tri-Staple 2.0 45 mm Extra Thin/ Vascular (gray)	Underlying chylothorax	Catastrophic	Unsuccessful cardiopulmonary resuscitation
Seroma (patient 5)	Canine	Endo GIA 60 mm (unspecified)	Seroma	Minor	Resolved with medical management

TABLE 4 Reasons for lung lobectomy.

Reason for lung lobectomy	Number of lung lobectomy procedures
Pulmonary mass	15
Pulmonary bulla	13
Abscess/granuloma	7
Lung lobe torsion	2
Penetrating wounds	2
Iatrogenic lung lobe laceration	2
Adhesions	2
Spontaneous pneumothorax	1
Pyothorax (grass awn)	1
Idiopathic pleural effusion	1

The median hospitalization time was two days. The median for thoracostomy tube removal was two days. Thoracostomy tubes used consisted of 12, 14, and 16 gauge sizes.

The reason for lung lobectomy in this study varied widely with pulmonary masses, bullae, and abscesses/granulomas as the most common reasons (Table 4). Histopathologic reports were available for 15 pulmonary masses which consisted of pulmonary adenocarcinomas (3/15), unclassified carcinomas (10/15), neuroendocrine carcinoma (1/15), and metastatic osteosarcoma (1/15). Complete margins were obtained in the majority of cases (13/15). One case had narrow (<0.1 mm) margins and one case had incomplete margins.

4 | DISCUSSION

Lung lobectomies were performed with minimal complications using Endo GIA staplers via an open thoracic approach for a variety of reasons in this study. This included pulmonary masses, pulmonary bullae, lung lobe torsion, abscesses/granulomas, idiopathic pleural effusion, penetrating wounds, spontaneous pneumothorax, pyothorax secondary to a grass awn, iatrogenic lung lobe laceration, and adhesions (Table 4).

Complications in this population were uncommon. The majority of intraoperative complications were addressed routinely with hemoclip application or various methods of hemostasis. In those cases, successful leak tests and hemostasis were ensured prior to closure. There were no instances of major complications perioperatively. The four cases that were classified under catastrophic complications were likely related to comorbidities rather than direct impact of surgery, surgical technique, or stapler employed. There were no indications intraoperatively (i.e., hemorrhage or air leakage) that would indicate complications regarding lung lobectomy.

To date, this is the first study describing the successful use of the Endo GIA stapler in vivo for lung lobectomy in open approach thoracic surgery. As evidenced by minimal complications in this study, the Endo GIA stapling device proves to be a safe and efficient alternative to previous staplers. Previous literature on stapled lung lobectomies utilizing TA staplers reported major postoperative complications in 5/87 (5.8%) cases and consisted of hemothorax, pulmonary hypertension, and recurrent pneumothorax.[16] These findings may highlight the importance of multiple rows of staples and smaller compressed staple heights to reduce postoperative complications.

A recent study that used a Vascular/Medium (tan) Endo GIA Tri-Staple device (45 or 60 mm length) for lung lobectomy in non-diseased cadaveric lungs documented that all staple sites withstood a maximum leak pressure of 40 cmH_2O.[14] Another previous cadaveric study compared suture ligation to the Endo GIA Tri-Staple 2.0 Extra Thin/Vascular (gray) stapler for lung lobectomy and demonstrated no evidence of air leakage following stapled lobectomies.[3] These studies highlight the Endo GIA staple line and its ability to withstand various leak pressures. In a study that compared LigaTies with TA staplers during thoracoscopic-assisted hilar lung lobectomies in feline cadavers, 4/10 stapled sites leaked at a mean pressure of 22 cmH_2O; however, TA staplers did not leak when the staple line was less than or equal to 5 mm from the hilus.[17] The aforementioned studies validate Endo GIA stapler use for lung lobectomies and indicate that different staplers may yield different leak pressures in dogs and cats depending on stapler placement on lung lobes.

Mainstream use of the Endo GIA stapler in clinical settings may be beneficial in the event of thoracoscopic procedures converting to open.[9] The Endo GIA stapler can still be implemented in this scenario rather than switching to a more standard stapler during the open procedure. This practice may ultimately reduce used materials and costs. Comparable complication rates between Endo GIA staplers and standard staplers may facilitate regular use of the Endo GIA stapler.

The Endo GIA stapler was chosen by this institution for its various unique properties. An articulating anvil and 360° axial rotation facilitates accurate and optimal stapler placement on the lung lobe, particularly in difficult to reach areas. Additionally, all Endo GIA staplers contain three staggered rows on each side of the blade and provides a simultaneous staple/cut function.[14] This eliminates the need for transection of the lung lobe after

traditional staplers are fired. These attributes may be particularly useful in deep cavities with poor visualization during a median sternotomy. These unique features make the use of the Endo GIA stapler in an open approach a viable option.

Our retrospective study highlights the use of the Endo GIA stapler with a variety of lung pathology. No complications were reported in infectious cases at the 14-day follow-up which suggests a high success rate for use on diseased lungs. This is an important consideration when appropriate margins are unable to be obtained. St Blanc et al. also highlighted advantages of the small staple size produced by Endo GIA Tri-Staple 2.0 Extra Thin/Vascular (gray) staplers and specifically that it provided a more complete seal and as a result reduced air leakage, hemorrhage, and potential thoracic contamination regarding infectious or neoplastic cases. Compression from the Endo GIA stapler on either side of the transection line may also facilitate reduced leakage and contamination rates.[4] Moreover, the Endo GIA Tri-Staple design caused no visible tissue trauma in vivo after clamping in comparison to similar stapler models.[12] Histopathologic margins should not be altered as this stapler offers gentle tissue compression, along with B-shaped staples on compression, allowing for continued capillary perfusion to the staple line.

Limitations of the study include a small sample size of patients with various lung pathology, as well as its retrospective nature. In some cases, surgery reports were lacking detail regarding Endo GIA cartridges used. Another limitation is the change in the Endo GIA model (Universal to Tri-Staple) part way through the study. Although many features of both models are similar (articulation, axial rotation, varied cartridge lengths, staggered triple staples, and simultaneous stapling/cutting), the stepped stapler compression of the Tri-Staple Endo GIA model was a novel feature compared to the flat compression of the Universal Endo GIA stapler. Ideally, one stapler model would be used in the study. The Endo GIA stapler is notably more expensive than that of traditional models, but its unique features may add efficiency and ease of use and thus save expenses in other areas. A larger inventory may be required for addition of stapler use in a clinical setting, unless the Endo GIA stapler ultimately phases out TA stapler use.

This study demonstrates the successful implementation of Endo GIA staplers in open approach lung lobectomies. This stapler has many distinct features that may offer advantages in a variety of cases. Future studies are required to compare complication rates between lung lobectomies performed with the TA stapler versus the Endo GIA stapler, which is beyond the scope of this study.

AUTHOR CONTRIBUTIONS

Weaver CT, DVM: Contributed to study design, record identification, data acquisition and evaluation, and drafted the manuscript. Barbur LA, DVM, DACVS (Small Animal): Contributed to study conception, study design, and revised the manuscript.

CONFLICT OF INTEREST STATEMENT

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

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