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Absorbable fixation straps for laparoscopic gastropexy in dogs

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Abstract

Objective: To evaluate the feasibility and efficacy of laparoscopic absorbable fixation straps (AFS) for laparoscopic gastropexy in dogs.

Study design: Cadaveric and prospective clinical study.

Animals: Five dog cadavers for the cadaveric study; 12 dogs for the clinical study.

Methods: The pyloric antrum was affixed to the abdominal wall laparoscopically by applying a series of straps. The cadaveric study assessed potential challenges during the procedure and stomach mucosal penetration. For the clinical study, the total duration of surgery, time to complete the gastropexy, and the number of straps used were recorded. Ultrasound evidence of adhesion, complications, and weight were monitored at 7, 30, and 90 days after surgery. Owner satisfaction was evaluated at the 6-month follow-up.

Results: The total duration of surgery was 25.8 minutes (range, 19-39; SD, 6.7), and the time to complete the gastropexy was 10.1 minutes (range, 7-19; SD, 3.9). The linear regression analysis revealed an inverse correlation between the time to complete the gastropexy and the order of the surgeries ($r^2 = 0.75$, $P < .05$). No complications were recorded. Ultrasound examination was used to confirm gastropexy at all follow-ups.

Conclusion: Laparoscopic gastropexy with AFS was performed in both cadavers and clinical animals with minimal complications. Persistent adhesion was demonstrated during ultrasound evaluations and in one postmortem evaluation.

Clinical significance: This novel laparoscopic technique can be employed safely, effectively, and reasonably quickly, and the learning curve is expected to be relatively short.

1 | INTRODUCTION

Gastric dilatation-volvulus (GDV) is a common and often fatal condition chiefly affecting large and giant breed dogs.[1] To prevent its occurrence, prophylactic gastropexy is routinely advocated for dogs at risk. The procedure has traditionally been performed through a laparotomy; however, minimally invasive methods have emerged and gained popularity in recent years, with reports of lower postoperative morbidity and a quicker recovery time.[2-4] Several procedures have been described, which include laparoscopy-assisted gastropexy (LAG)[4-8] and the completely intracorporeal approach (ie, laparoscopic gastropexy [LG]).[9-15] Compared with open gastropexy[1,16-20] and LAG, LG is less invasive, has a lower rate of complications related to wound healing, and has faster postoperative recovery. However, it is a longer surgery and requires more surgical skill, meaning the learning curve is steeper.[21] Because LAG is relatively less technically challenging, it has been widely used for prophylactic gastropexy. Mathon et al[22] proposed the use of extracorporeal knot tying with knots buried in the subcutaneous tissue. Mayhew and Brown[11] alternatively introduced the use of a laparoscopic suture device instead of a traditional needle driver to facilitate intracorporeal suturing and knotting. After having considered the diffusion of knotless barbed sutures, many authors have proposed that LG could be performed without the difficulty of intracorporeal knot tying in dogs. Indeed, the use of barbed tissue in LG with traditional laparoscopic needle holders[13,15] or laparoscopic suture devices[9,10] has been described. Use of the knotless barbed suture technique allows the surgery to be performed in a mean duration of 20.8[13] to 70 minutes[15] and results in efficient biomechanical findings for gastropexy.[23-25]

Among the surgical laparoscopic techniques available to avoid intracorporeal knot tying, the use of absorbable fixation straps (AFS) has been described for fixating the mesh when repairing abdominal hernias in man.[26] Researchers demonstrated that the mean range of the maximum load to failure of acute gastropexy did not differ when using AFS or barbed sutures in a previous ex vivo study.[27] We speculated that AFS should be employed to create permanent adhesions during LG.

In this study, we evaluated the feasibility and efficacy of laparoscopic AFS in LG (LG-AFS) in dogs. Our hypothesis was that AFS could be used to create permanent adhesions during laparoscopic gastropexy. We developed the new technique and overcame the initial learning curve through cadaveric work and then assessed the clinical performance of the technique in dogs susceptible to GDV.

2 | MATERIALS AND METHODS

2.1 | Animal welfare

The study was approved by the Ethics Committee for Clinical and Zootechnical Studies of the Department of Emergency and Organ Transplantation, University of Bari "Aldo Moro".

Recruitment of dogs for the study was authorized by the owners through written consent. The owners were specifically informed of other established gastropexy methods, and it was communicated that the proposed approach might not deliver a permanent gastropexy sufficient to prevent gastric volvulus. For the cadaveric study, cadavers of dogs that had died from causes unrelated to this study were donated by their owners.

2.2 | Cadaveric study

Cadavers (n = 5) of medium- and large-sized dogs euthanized at the Section of Veterinary Clinics and Animal Production, University of Bari, Italy between January 2018 and June 2018 for reasons unrelated to our study were used. The owner's permission was obtained for each dog. After euthanasia, cadavers were refrigerated at 4°C for 24 to 36 hours and then stored at room temperature for 4 to 6 hours before performing the surgical procedure. Medium-sized dogs were defined as those weighing 12 to 20 kg, with a body condition score of 3 (BCS; 1-5 scale). Large-sized dogs were defined as those weighing >20 kg, with a body condition score of 3.

2.3 | Laparoscopic gastropexy-AFS surgical procedure

The AFS used (SecureStrap absorbable fixation device strap; Ethicon, Cincinnati, Ohio) were 6.7 × 4 mm and made of a blend of polydioxanone and an L(−)-lactide and glycolide copolymer. Each AFS had two points of fixation designed to secure the prosthetic material to the soft tissue (Figure 1). The AFS were applied with a laparoscopic applicator device (0.5 × 36 cm) that could hold 25 AFS.

The surgical procedures were performed by the same surgeon (L.L.), who has performed ~100 laparoscopic procedures per year. The dogs were positioned in dorsal recumbency. A Veress needle was inserted in the ninth right intercostal space as described elsewhere.[28,29] A pneumoperitoneum was created with a maximum pressure of 8 mm Hg CO_2 by using a laparoscopic insufflator (Karl Storz Endoskope, Tuttlingen, Germany). Three 6-mm stainless steel reusable cannulas (Karl Storz Endoskope) were placed as described by Mathon et al[22] (Figure 2). The central cannula was placed for the telescope at the level of the umbilicus. Another cannula was positioned in the left cranial abdomen lateral to the rectus abdominis, just caudal to the third left mammary

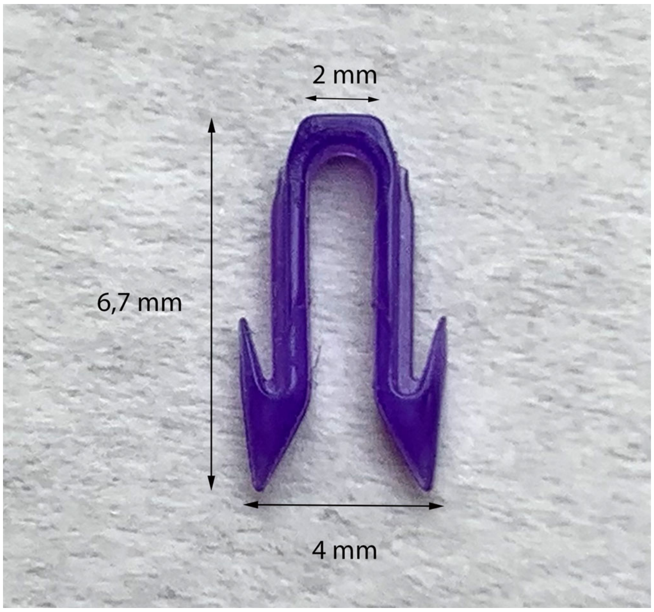

FIGURE 1 Image of the absorbable strap (SecureStrap, Ethicon)

FIGURE 2 Portal positioning. Telescope was inserted through the umbilical port

gland. The last cannula was placed in the right caudal abdomen lateral to the rectus abdominis, just caudal to the fourth right mammary gland.

A 5-mm laparoscopic 30° telescope (Karl Storz Endoskope) was inserted into the umbilical portal, and two 5-mm laparoscopic Babcock forceps were inserted into

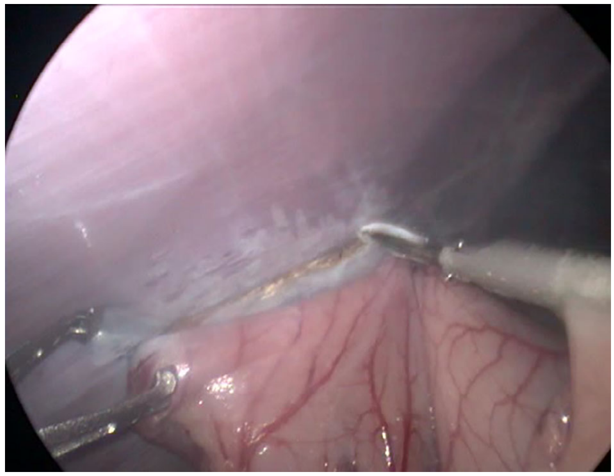

FIGURE 3 Serosa cauterization. The abdominal wall serosa and stomach serosa were cauterized with a harmonic scalpel for a length of 4 to 5 cm

the instrumental portals. After the pyloric antrum was visualized, the stomach was grasped and moved to the right abdominal wall at the paracostal level (12th costal) to locate the exact area for stomach fixation.

The right instrument was removed, and the AFS applicator was inserted to suspend the stomach on the abdominal wall with a cranial and caudal strap application. Then, a harmonic scalpel (Ultracision ACE; Ethicon) was inserted to create cauterization lines on the abdominal wall and stomach serosa, according to an ideal line along the longitudinal axis of the stomach for a length of 4 to 5 cm (Figure 3). Fixation of the stomach was completed by applying an appropriate number of straps to cover the cauterization line and maintain the apposition accomplished by pulling the stomach manually (Figures 4 and 5). The total duration of surgery was calculated from the insertion of the Veress needle to the interruption of the pneumoperitoneum; the time to complete the gastropexy was calculated from the insertion of the third portal to the application of the last strap.

At the end of the procedure, the pneumoperitoneum was interrupted, gas was deflated, and cannulas were removed. Next, the stomach was harvested to evaluate any inadvertent luminal penetration of the straps. Moreover, the surgeon reported the likelihood of the procedure to be successfully completed, the adequate position for the portals, and any corrections to the technique.

2.4 | Clinical study inclusion criteria

For this prospective preliminary study, we included dogs that belonged to breeds susceptible to GDV and without

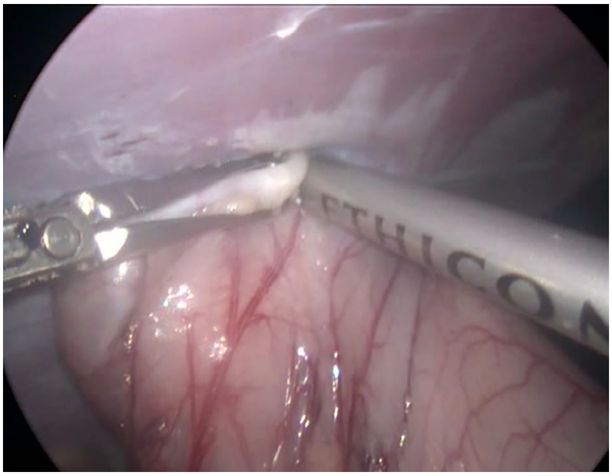

FIGURE 4 Stomach fixation. The fixation of the stomach was completed by applying a proper number of straps to allow coverage of the cauterization line and to maintain the apposition accomplished by pulling the stomach manually

FIGURE 5 Stomach fixation completed

any history of disease for at least 3 months, from June 18 to January 2020. All surgical procedures were performed by the same surgeon (L.L.).

2.5 | Anesthetic protocol

All dogs were premedicated with an IM administration of 10 μg/kg acepromazine (Prequillan, 10 mg/mL; Fatro, Bologna, Italy), and after 15 minutes, 0.3 mg/kg of methadone (Semfortan, 10 mg/mL; Dechra, Torino, Italy). After adequate sedation had been achieved, a cephalic vein was cannulated for IV administration of fluids and drugs. General anesthesia was induced with propofol (10 mg/mL; Fresenius Kabi, Bad Homburg, Germany) at 5 mL/kg IV, and the animals were intubated and connected to a rebreathing circuit. Anesthesia was maintained with inhaled isoflurane and pure oxygen (FiO_2 >0.8). All dogs were mechanically ventilated during the entire procedure in volume-controlled mode (Servo-I; Maquet, Rastatt, Germany) with a tidal volume of 15 mL/kg, an inspiratory to expiratory ratio of 1:2, inspiratory pause of 25% of the inspiratory time, and a positive end-expiratory pressure of 5 cm H_2O. The respiratory rate was adjusted to the end-tidal CO_2 level, which was maintained between 40 and 55 mm Hg. The preoperative antimicrobial prophylactic therapy consisted of an IM injection of amoxicillin and clavulanic acid (20 mg/kg, Synulox; Zoetis Italia, Rome, Italy). Perioperative analgesia was provided by the IM administration of robenacoxib (1 mg/kg, Onsior; Novartis, Varese, Italy).

2.6 | In vivo LG-AFS surgical procedure

The surgical procedure was performed in the same setting as the cadaveric study described previously. The skin was clipped routinely and aseptically prepared and draped. At the end of the procedure, the pneumoperitoneum was interrupted, gas was deflated, and cannulas were removed. The portals were closed with two layers of absorbable interrupted horizontal mattress pattern sutures (polyglactin 910). The total duration of surgery was calculated from the insertion of the Veress needle to the interruption of the pneumoperitoneum; the time to complete the gastropexy was calculated from the insertion of the third portal to the application of the last strap.

2.7 | Postoperative regimen and aftercare

The dogs were discharged on the same day of the surgery. Feeding was allowed 8 hours after recovery from anesthesia, and the total food for each day was split into four feedings for at least 7 days after surgery. Robenacoxib (1 mg/kg, Onsior; Novartis, Varese, Italy) was administered orally once per day for 5 days after surgery. Owners were advised to keep their dogs rested and not allow them to exercise for at least 7 days postoperatively. Skin wounds were covered with sterile dry dressing, and the application of 2% chlorhexidine solution every 3 days was recommended for disinfection. The owners were instructed to return to the hospital for clinical evaluation at 7, 30, and 90 days postsurgery.

2.8 | Clinical evaluation

Dogs were clinically evaluated before surgery (T0) and 7 (T7), 30 (T30), and 90 days (T90) after surgery. Weight, wound healing complications, vomiting, anorexia, lethargy, diarrhea, and episodes of gastric dilatation were recorded. Longer follow-up assessments were performed by telephone interviews. Owners were questioned about the general condition of their dogs, occurrence of GDV episodes, their satisfaction (excellent or not) with postoperative care, and whether they would recommend the technique to other owners.

2.9 | Ultrasound examination

Ultrasound examination (Logiq 400, equipped with a convex 5.5 MHz probe; GE, Chicago, Illinois) was performed at T7, T30, and T90. For the gastropexy to be considered successful, the stomach wall had to be thicker than normal and hypoechoic, and its serosal surface had to be indistinguishable from that of the abdominal wall. Gastropexy adhesion was considered present when there was unit motion between the stomach and body wall at the gastropexy site.[8,13]

2.10 | Postmortem analysis

One neapolitan mastiff died 20 months after surgery of a small intestinal volvulus; no complication related to surgery had been noted during follow-up. The owner agreed to a necropsy.

The gastropexy area was harvested in an oval shape, 7 cm in length, consisting of the right portion of the transverse muscle of the abdomen and the anchored stomach. The tissues were stored in 10% buffered formalin, treated with Histokinette TP1020 Leica tissue processor (Leica Microsystems, Milan, Italy), embedded in paraffin, and subsequently cut with a microtome at 4 μm and stained with hematoxylin and eosin and Masson's trichrome. Images of the tissue were acquired by using a D 4000 Leica DMLS microscope (Leica Microsystems) equipped with a camera and image analyzer (NIS elements-BR; Nikon Instruments Europe, Amsterdam, The Netherlands).

2.11 | Statistical analysis

Data are presented as mean, range, and SD for time and parametric data; and median, range, and interquartile range (IQR) for the number of straps employed. Data were analyzed in MedCalc Statistical Software version 16.4.3 (MedCalc Software, Ostend, Belgium; https://www.medcalc.org; 2016). Data normality was verified by using the Shapiro–Wilk test. Weights at different follow-up time points were compared by using one-way analysis of variance. Linear regression analyses were performed to evaluate the correlation of the order of surgical procedures with the time to complete the gastropexy. The significance level was set at $P < .05$.

3 | RESULTS

3.1 | Cadaveric study

Among the five dog cadavers, two were medium-sized dogs with a mean weight of 14.9 kg (range, 12.5-17.4; SD, 3.5), and three were large-sized dogs with a mean weight of 34.9 kg (range, 27.5-40.1; SD, 6.6). The size and weight of the dogs did not substantially affect the procedures.

All procedures were completed successfully. The positioning of the portals was adequate to complete the procedures. No particular challenges were encountered, except excessively acute deployment of straps due to abdominal conformation. In cases with angles presumably less than 60°, an assistant gently pressed the abdomen externally by hand to modify the angle between the straps' applicator and abdominal wall. The mean time taken to complete the gastropexy was 14.3 minutes (range, 12-17; SD, 5.4), and the mean total duration of the surgery was 36.1 minutes (range, 27-47; SD, 8.3). No intraluminal penetration of the straps was found at examination of the stomach mucosa after the procedures (Figure 6).

3.2 | Clinical study

3.2.1 | Population

Twelve (six male and six female) dogs were enrolled in the study. These included six Great Danes, four Neapolitan mastiffs, one Dogue de Bordeaux, and one Cane Corso Italiano, with a mean weight of 59.33 kg (range, 38.2-83.1; SD, 12.1) and ages ranging from 11 months to 5 years. Only one dog had a history of gastric dilatation, which occurred 3 months before the surgical procedure and was originally treated conservatively without surgery.

3.2.2 | Surgery

No intraoperative complications were reported during the surgeries. The mean duration of surgery was

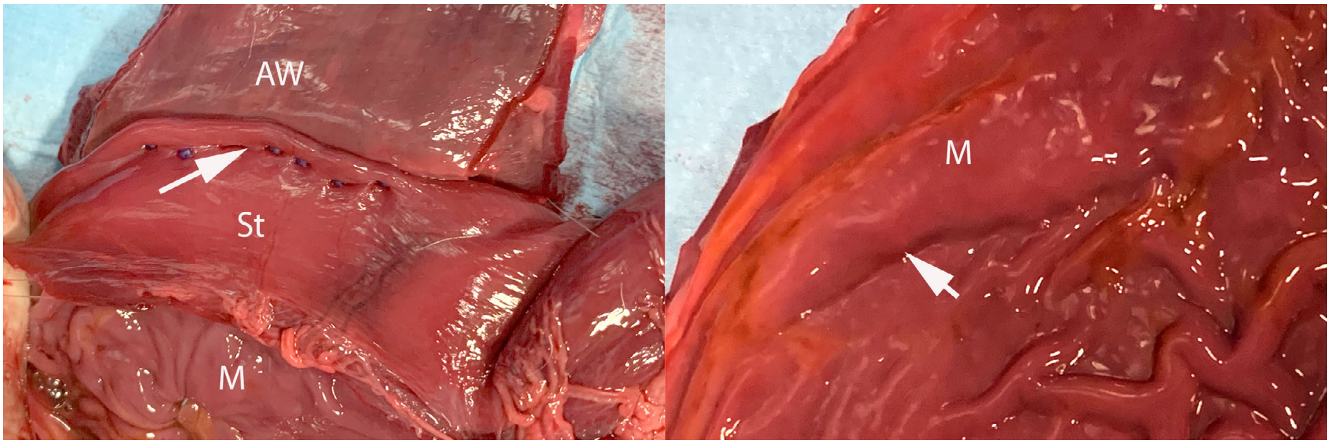

FIGURE 6 Representative images of LG-AFS construct performed in a dog cadaver after harvesting. The image at left is the serosal side of the stomach; the image at right is the mucosal side, highlighting the integrity of the mucosa and the absence of any signs of strap penetration. Arrow, AFS series. AFS, absorbable fixation strap; AW, abdominal wall; LG, laparoscopic gastropexy; M, mucosa; St, stomach

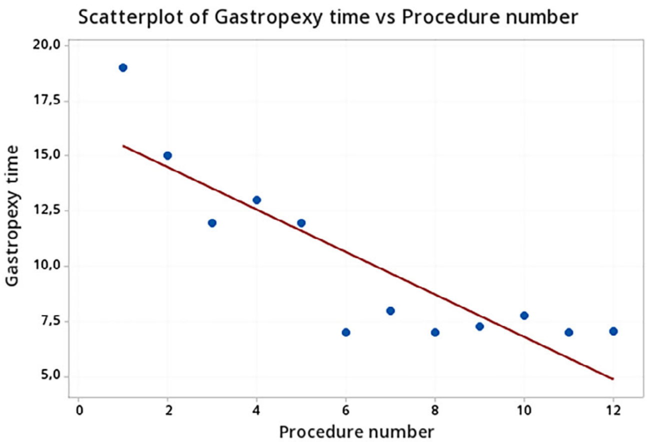

FIGURE 7 Linear regression analysis of gastropexy time vs the order of procedures was highly correlated ($r^2 = 0.75; P < .05$)

25.8 minutes (range, 19-39; SD, 6.7), and the time to complete the gastropexy was 10.1 minutes (range, 7-19; SD, 3.9). The median number of straps used to complete gastropexy was nine (range, 7-11; IQR, 1.75). The linear regression analysis of the time to complete the gastropexy vs the order of procedures resulted in a negative correlation ($r^2 = 0.75$; $P < .05$; Figure 7).

3.2.3 | Clinical evaluation

The mean weights at T0 (59.33 kg; range, 38.2-83.1; SD, 12.1), T30 (60.3 kg; range, 38.2-83.1; SD, 12.1), and T90 (60.95 kg; range, 39.2-63.4; SD, 12.5) were not different ($P < .05$). No wound healing complications, vomiting, anorexia, lethargy, diarrhea, or episodes of gastric dilatation were recorded at any follow-up examinations. All dogs appeared healthy at physical examination and had no abnormal gastrointestinal signs during the postoperative period. Telephone interviews with owners 6 months after surgery confirmed the absence of any complications. All owners (12/12) expressed excellent satisfaction and stated that they would recommend prophylactic LG to other owners and breeders.

3.2.4 | Ultrasound examination

Ultrasound of all the dogs at T7, T30, and T90 revealed evidence of thickening of the abdominal wall and seromuscular layer of the stomach in the gastropexy area. The absence of signs of sliding between the serosa of the stomach and the abdominal wall during breathing confirmed the success of the gastropexy (Figure 8). The straps were not detected by ultrasound at any follow-up.

3.2.5 | Postmortem analysis

One Neapolitan mastiff died 20 months after the surgery of a small intestinal volvulus. No complication related to surgery had been noted during follow-up. When necropsy was performed in the dog, complete adhesion between the peritoneal serosa at the right epigastric region and the stomach serosa was observed for a length of 4 to 5 cm (Figure 9).

The adhesion zone consisted of a dense fibrous connective tissue that infiltrated the perimysium and endomysium of the striated muscle of the abdominal wall and the serous and muscular tunic of the stomach, intimately fusing the two structures. The fibrotic connective

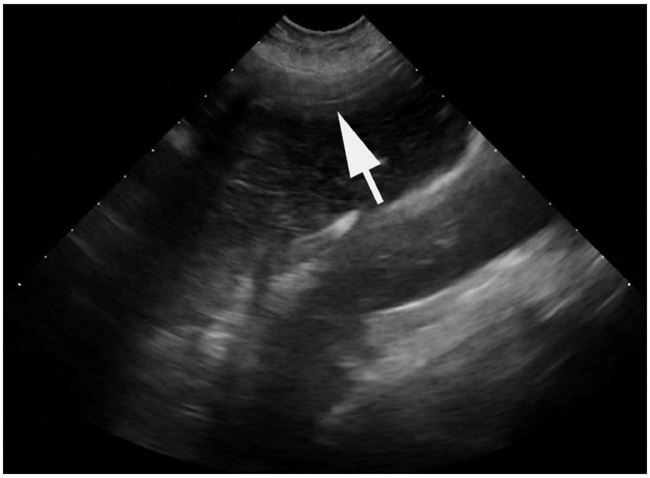

FIGURE 8 Representative image of ultrasound performed at 90 days after surgery. No signs of sliding between the serosa of the stomach and abdominal wall during breathing confirmed gastropexy success. Gastropexy site (arrow)

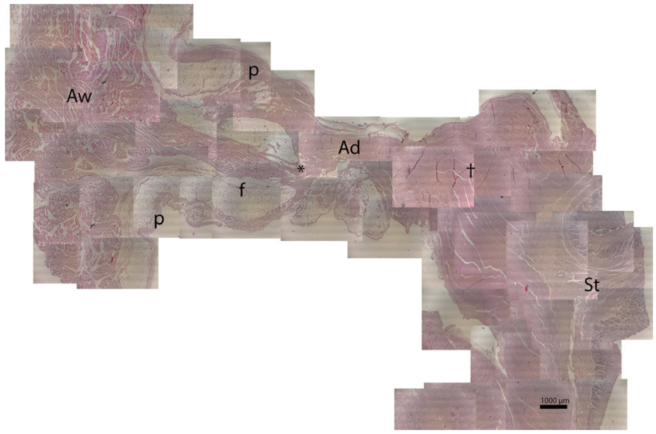

FIGURE 10 Hematoxylin and eosin stain. The image was obtained by combining several ×4 fields of view. †The connective tissue is interposed between the striated muscle of the AW and the muscle of the stomach. *The peritoneum has been fused into the serosa of the stomach through a dense and continuous connective tissue containing adipose tissue (f). AW, abdominal wall; Ad, adhesion band; f, adipose tissue; p, peritoneum; St, stomach. Scale bar = 1000 μm

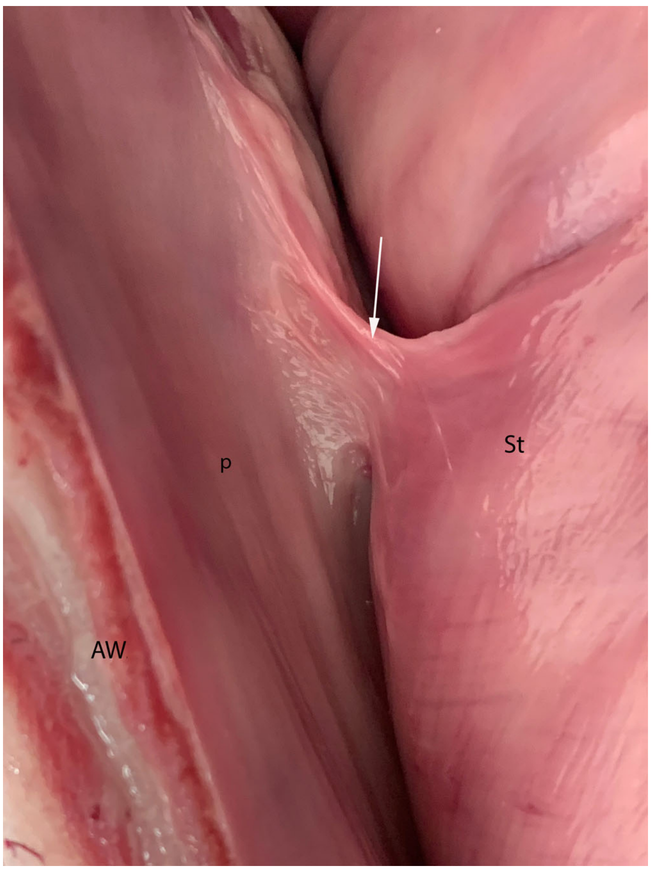

FIGURE 9 Postmortem evaluation at 20 months after LG-AFS. The adhesion band created between the peritoneal and stomach serosa (arrow). AFS, absorbable fixation strap; AW, abdominal wall; LG, laparoscopic gastropexy; p, peritoneum; St, stomach

tissue was formed of fibers located parallel to each other with mature fusiform-looking fibroblasts in an amorphous substance and numerous capillaries, venules, and small arterioles of tortuous appearance with intact but prominent intimae.

In the areas adjacent to the fibrous connective tissue, there were loosely arranged collagen fibers of heterogeneous dimensions mixed with a variable quantity of adipose tissue. No residuals of the straps used to perform the gastropexy were present in the tissues analyzed. The sections colored with Masson's trichrome confirmed the presence of a thick layer of fibrous connective tissue formed by corrugated fibers whose course was oriented in the direction of the forces exerting traction on them (Figures 10-12).

4 | DISCUSSION

In this study, we evaluated the feasibility and efficacy of a laparoscopic AFS device for prophylactic LG in dogs susceptible to GDV. The results of the cadaveric study provided evidence that the procedure was feasible for the laparoscopic surgical setup investigated. The procedure was successfully completed in a laparoscopic environment reasonably quickly without complications. No evidence of AFS penetration in the stomach mucosa was detected in the harvested specimens. We used 5-mm Babcock grasping forceps to create a seromuscular plica of the stomach to ensure that the AFS penetrated only

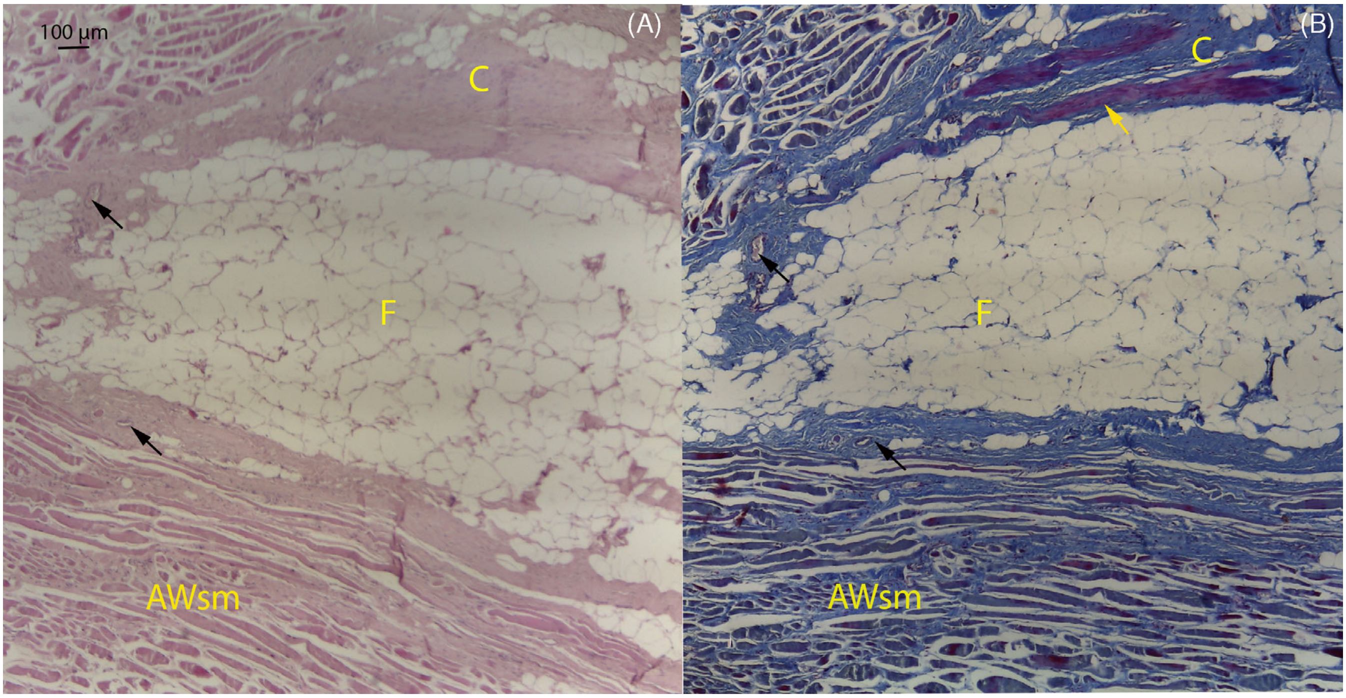

FIGURE 11 Representative images of the central part of the adhesion (×4). A, Hematoxylin and eosin stain. B, Trichrome stain of Masson. The striated muscle fibers of the abdominal wall (AWsm) are dispersed in the connective tissue (C) and adipose tissue (F). In the adhesion, mature fibroblasts, numerous capillaries, and small arterioles (black arrows) can be observed. Some bands of immature collagen were interposed in organized mature collagen (yellow arrow)

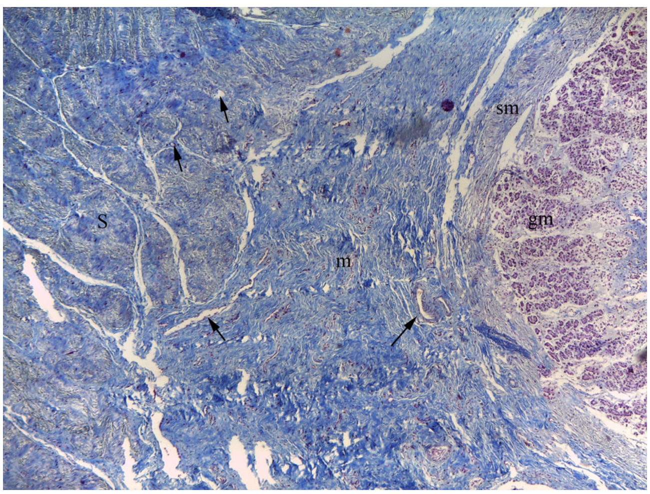

FIGURE 12 Masson's trichrome (×4). Representative image of the stomach side. All layers contain plenty of patent and intact vessels (arrows). gm, gastric mucosa; m, muscularis; S, serosa; sm, submucosa

the seromuscular layer for the constructs of the present study. However, care should be taken to ensure that the gastric mucosa is not penetrated by the AFS; penetration of the gastric mucosa is a potential limitation of this technique and traditional gastropexy.[22]

Minimally invasive gastropexy techniques, both LAG and LG, decrease morbidity and increase the possibility of implementing additional indications for laparoscopic procedures.[15] The advantages of AFS are essentially the efficiency and simplicity of the application of the straps, which allow for a complete gastropexy to be performed in ~10 minutes. The mean time to complete the gastropexy in this study was acceptable for this type of surgery. The time to complete the gastropexy during LG with incorporeal suture knotting was recently reported to be 35.2 minutes[13] with smooth polydioxanone suture material and the hand knot technique. The use of barbed sutures has allowed gastropexy to be completed in 20.8[13] to 70 minutes.[15] Although the LAG technique has been considered a very simple and rapid procedure, the duration of surgery ranges from 22[6] to 28 minutes.[11] One advantage of LG-AFS that contributes to the decreased duration of surgery is the elimination of the requirement to tie intracorporeal knots, resulting in a lower requirement of technical skill and less extensive training.

The linear regression analysis of the duration of surgery compared with the order of procedures in this study revealed that the time to complete the gastropexy was reduced from 19 to 7 minutes as the surgeon gained experience with the procedure. According to data reported for other LG techniques, after 20[13] or 30[9,10] procedures, the time to complete the gastropexy can be reduced by 50%. The use of barbed sutures was equally efficient when performing LG compared with an endoscopic needle driver with the same type of barbed suture but was associated with a longer learning curve.[10]

These data provide evidence to support the claim that the LG-AFS technique is rapid and, because it does not involve intracorporeal sutures, requires less surgical skill and is, therefore, simpler and easier to perform.

For the first time, we performed a postmortem evaluation of the adhesion of the stomach serosa to the abdominal wall in a dog who died of causes unrelated to GDV 20 months after LG-AFS. The pathological results supported our hypotheses that the gastropexy would be effective because a consistent, mature connective tissue was found between the abdominal wall and the stomach where the AFS was implanted. However, additional postmortem evaluation data from other dogs are required to corroborate the findings from this one case.

Serosa debridement promotes strong adhesion between the gastric and abdominal walls. In particular, the use of electrosurgical devices removes the mesothelium of the peritoneum and, therefore, stimulates fibrous adhesion, reduces bleeding, eliminates the risk of inadvertent luminal penetration during cutting, and provides a reference point while the stomach is sutured to the body wall.[15] We cauterized the abdominal peritoneal serosa and stomach seromuscular layer surfaces with a harmonic scalpel before completing the gastropexy because it was quick, controlled the bleeding, and facilitated orientation of the abdominal wall to complete gastropexy, as suggested by Mathon et al.[22]

The AFS used in the present study contained polydioxanone, which are like strand sutures and can be used in gastropexy. Polydioxanone sutures were used in this study because they are associated with lower tissue drag and capillary effect compared with braided sutures.[11,13] Researchers have shown that absorbable knotless (barbed) monofilament sutures lose 50% of their tensile strength 3 weeks after implantation.[23,30] The absorption profile of the copolymer blend in the AFS used in the present study was minimal during the first 2 weeks,[26] but absorption was essentially complete by approximately 12 to 18 months.[26,31] In the only case that was evaluated postmortem in our study, no residuals of the straps were still present 20 months after the surgery. To the best of our knowledge, it is not known to what extent AFS would contribute to the tensile strength of a gastropexy 3 to 8 weeks after surgery. In addition, the mechanical strength of the adhesion created during the healing process when AFS are used is not known.

The integrity of gastropexy was evaluated in vivo by ultrasound, as described elsewhere.[9,24] Ultrasound images revealed adhesion of the stomach and body wall layers during follow-up assessments. Laparoscopic gastropexy-AFS resulted in an effective, durable adhesion similar to other LG techniques, and ultrasound evidence did not differ from that in previously published papers,[11,32,33] even when it was performed with a single simple continuous pattern.[13,15,21,34] The straps were not detected by ultrasound during the follow-up. To the best of our knowledge, there are no reports describing the acoustic features during the resorption of the straps employed in this study; therefore, additional studies are warranted to investigate this issue.

Many authors have reported some complications regarding the healing of surgical wounds, such as inflammation, edema, erythema, or even seromas of the suture line.[1,32,35] Loy Son et al[35] reported an access-related complication rate of 10% with LAG. No complications were reported in the study reported here. All cases were evaluated after 6 months by a telephone interview with the owner. The results revealed high owner satisfaction with the procedure. Owners stated they would consider an LG-AFS for a future at-risk dog and would recommend the procedure to other owners. We believe that this finding is encouraging for new laparoscopic surgeons who are considering proposing this procedure to owners of dog breeds susceptible to GDV.

Our study had some limitations. One was the lack of reevaluating the gastropexies under direct view or laparoscopy during follow-up. Unfortunately, none of the owners agreed to another laparoscopy for this purpose. Although only one dog was evaluated postmortem, the results provided encouraging evidence for the effective gastropexy achieved with LG-AFS; however, other cases should be evaluated postmortem to confirm these data. Another limitation was the lack of postoperative biomechanical testing. This study was performed in client-owned dogs, and it was impossible to test gastropexy constructs in a clinical study. Furthermore, to perform the tensile strength tests, the constructs would lead to the destruction of gastropexy; therefore, only the dog that died underwent a histological examination. The lack of evidence regarding how the AFS contributes to adhesion healing should be addressed in experimental models, and additional studies should focus on this aspect. Another limitation was the number of dogs investigated. Increasing the sample should be addressed in future studies.

This study provides promising evidence for LG-AFS as a reliable technique for gastropexy in terms of postoperative morbidity and its quick and simple nature. Laparoscopic gastropexy-AFS did not require a laparoscopic suture and therefore had low technical demands. We speculate that LG-AFS could be considered for minimally invasive prophylactic gastropexy in dogs.

AUTHOR CONTRIBUTIONS

Lacitignola L, DVM, PhD: Conceptualization of the study, methodology, formal analysis, investigation, data curation, original draft preparation, review and editing of the article, supervision, read and approved final version of the manuscript for publication; Fracassi L, DVM, PhD: Conceptualization of the study, investigation, read and approved final version of the manuscript for publication; Di Bella C, DVM, PhD: Investigation, read and approved final version of the manuscript for publication; Zizzo N, DVM: Investigation, original draft preparation, read and approved final version of the manuscript for publication; Passantino G, DVM: Investigation, read and approved final version of the manuscript for publication; Tinelli A, DVM: Investigation, read and approved final version of the manuscript for publication; Crovace AM, DVM, PhD: Investigation, read and approved final version of the manuscript for publication; Staffieri F, DVM, PhD: Conceptualization of the study, formal analysis, supervision, read and approved final version of the manuscript for publication.

CONFLICT OF INTEREST

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

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