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A Comparison of Laparoscopic and Belt-Loop Gastropexy in Dogs

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A simplified technique for laparoscopic gastropexy (group 1) was compared to belt-loop gastropexy (group 2) in eight adult male dogs randomly divided into two groups of four dogs each. Our hypothesis was that a satisfactory laparoscopic gastropexy would approximate the strength and operative time required for belt-loop gastropexy. Operative time, surgical complications, postoperative morbidity, gross and histological appearance, radiographic microvascularization, and maximal tensile strength were measured and compared between the two groups. All dogs recovered from surgery. No morbidity was associated with either procedure. The mean (±SD) duration of surgery was 69.75 ± 7.23 minutes for group 1 and 58.75 ± 7.63 minutes for group 2. Fifty days after surgery, the microvascular appearance of the gastropexy site was similar for both groups. Blood vessels were observed within each seromuscular flap but vascular ingrowth to the abdominal musculature was observed in only two dogs, one from each group. The maximum tensile strength at 50 days was 76.55 ± 22.78 for group 1 and 109.21 ± 22.29 N for group 2. Differences between surgical duration and maximum tensile strength were not statistically significant ($P > .05$). Histologically, all gastropexies consisted of an adhesion composed of dense fibrous connective tissue. The results of this study indicate that laparoscopic gastropexy provides a minimally invasive alternative to open abdominal prophylactic gastropexy in dogs.

NUMEROUS TECHNIQUES have been developed to provide gastric stabilization for prevention of recurrence of gastric dilatation-volvulus (GDV) in dogs, including permanent gastropexy, tube gastrostomy, incisional gastropexy, circumcostal gastropexy, muscular flap gastropexy, belt-loop gastropexy, and fundic gastropexy.[1-7] Other gastric fixation procedures, extrapolated from human surgical literature, include gastrocolopexy[8] and gastrojejunostomy[9] but these are rarely used. All of these procedures are performed using an open technique through a midline or paramedian celiotomy incision. Although controversy exists as to the most effective procedure, most are considered effective at reducing the frequency of recurrent gastric volvulus.[10] Because of the high mortality rate associated with gastric volvulus, these procedures may be used prophylactically in dogs considered at high risk.[3,4]

Laparoscopic surgery is commonly used in human surgery and is advocated over open surgery because of reduced tissue injury, reduced postoperative pain, shortened postoperative recovery, and early return to work.[11,12] Reported uses of laparoscopic surgery in veterinary medicine include renal and hepatic biopsy,[13,14] cryptorchidectomy,[15] ovariohysterectomy,[16] artificial insemination,[17] intestinal anastomosis,[18] and gastropexy.[19,20] Based on the suppositions that minimally invasive surgery may be requested by clients

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and may be beneficial to dogs, we developed a gastropexy technique which could be performed with minimal laparoscopic instrumentation. Our hypothesis was that a satisfactory laparoscopic gastropexy would approximate the strength and operative time required for belt-loop gastropexy, which has become our preferred open gastropexy technique. This paper describes a new laparoscopic gastropexy technique and compares the resulting adhesion to that created by belt-loop gastropexy.

MATERIALS AND METHODS

Eight sexually intact male dogs weighing more than 20 kg were used in this study in accordance with the Animal Welfare Act and Auburn University Institutional Animal Care and Use Committee guidelines. The dogs were divided into two groups of four dogs using a random digits table. Each dog was determined to be healthy before this study during a 14-day preconditioning period. This was based on the results of physical examination, complete blood count (CBC) and blood chemistries, including creatinine kinase (CK) and urinalysis. Rabies and DA_2PL-CPV vaccinations and anthelmintics were administered. During the preconditioning period and for the first 7 days after surgery, each dog was examined daily. Physical status, attitude, appetite, rectal temperature, heart rate, and respiratory rate were recorded.

Before surgery, each dog was fasted and premedicated with atropine sulfate (Fort Dodge Inc, Fort Dodge, IA) (0.04 mg/kg intramuscularly [IM]) and acetylpromazine (Promace, Fort Dodge Inc) (0.04 mg/kg; IM). General anesthesia was induced with thiopental (Pentothal, Abbott Laboratories, North Chicago, IL) (15 mg/kg; administered intravenously [IV]) and maintained by inhalation of halothane in oxygen. Lactated Ringer's solution (11 ml/kg/hr IV) was administered and vital signs monitored during surgery. All surgeries were performed by the same surgeon (ERW) and an assistant. Each procedure was performed with the dog in dorsal recumbency. An analgesic (Oxymorphone HCl, Pitman-Moore Inc, Washington Crossing, NJ) (0.05 mg/kg IM) was given before recovery from anesthesia and continued as needed for 24 hours after surgery. Water was provided after the dogs had recovered from anesthesia. Food was provided daily beginning the day after surgery.

Laparoscopic Gastropexy (Group 1)

A 1 cm incision through the skin and linea alba was made at the umbilicus. A 10 mm operating portal (Endopath Blunt Tip Surgical Trocar, Ethicon Inc, Somerville, NJ) was inserted through the incision under direct visualization and secured to the external rectus sheath with two No. 0 polypropylene stay sutures. Once the peritoneal cavity was insufflated with carbon dioxide to a pressure of approximately 8 cm of water, the laparoscope was inserted through the operating portal. Under laparoscopic visualization, two additional 10 mm instrument portals were inserted through 1 cm skin incisions, one caudal to the right costal arch at the lateral edge of the rectus abdominus and the other 2 cm left and midway between the xiphoid and umbilicus (Fig 1). A seromuscular flap centered over branches of the right gastroepiploic artery was elevated from the pyloric antrum approximately 4 cm from the pylorus using curved 10 mm endosurgical dissection scissors and 5 mm endosurgical tissue graspers. Because direct measurement of the endosurgical flap was not possible, flap size was estimated to be approximately 3 cm wide by 5 cm long based on known dimensions of the dissection scissors in the surgical videofield. The seromuscular pyloric antral flap was exteriorized through the rent in the body wall created by the right lateral portal. The skin incision was sharply extended 3 cm cranial and Metzenbaum scissors were used to undermine between the external and internal abdominal oblique muscles. The seromuscular flap was then tunneled between the external and internal abdominal oblique muscles and sutured to the external rectus fascia using six No. 0 chromic gut simple interrupted sutures. The carbon dioxide was vented and the operating portals removed from the abdomen. A

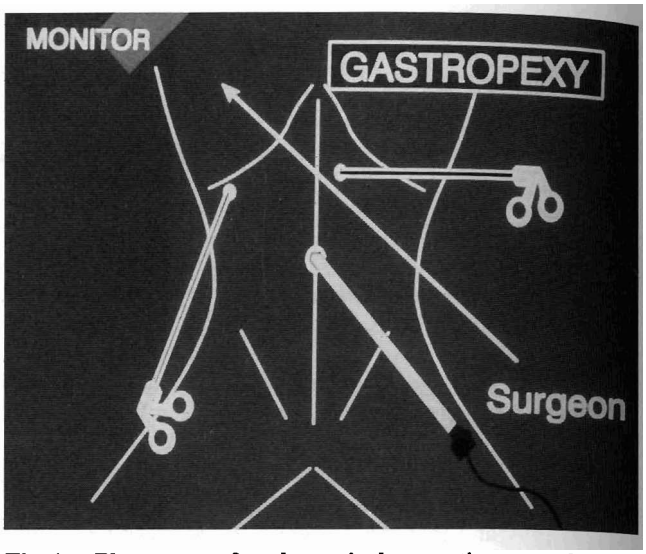

Fig 1. Placement of endosurgical operating portals. The laparoscope is inserted through an operating portal placed at the umbilicus. Two additional instrument portals are placed, one caudal to the right costal arch at the lateral edge of the rectus abdominus and the other 2 cm left of the midline and midway between the xiphoid and umbilicus. The surgeon operates from the dog's left flank and faces a monitor cranial to the right shoulder.

standard three layer closure was performed using two or three simple interrupted sutures in each layer.

Belt-loop Gastropexy (Group 2)

A 20-cm ventral midline abdominal incision was made, beginning at the xiphoid cartilage and extending caudal to the umbilicus. The linea was incised and self-retaining retractors inserted to provide exposure. A 3 cm by 5 cm seromuscular flap centered over branches of the right gastroepiploic artery was elevated from the pyloric antrum approximately 4 cm from the pylorus. Two incisions parallel to the costal arch were made in the right abdominal wall caudal to the last rib. The peritoneum and transverse abdominal muscle were undermined. The seromuscular, pyloric antral flap was pulled through the tunnel created in the abdominal wall and sutured to its original position on the stomach using six No. 0 chromic gut sutures.[6] A routine three-layer closure of the abdominal wall was performed.

Each wound was examined daily after surgery and a description recorded. Additionally, a CBC and differential and creatinine kinase measurement were performed on each dog 1, 3, and 7 days after surgery to detect possible differences in morbidity between groups.

All dogs were euthanatized 50 days after surgery using an intravenous euthanasia solution (Beuthanasia, Schering-Plough Animal Health Corporation, Kenilworth, NJ) (1 mL/5 kg IV). Before euthanasia, each dog was administered heparin (200 IU/kg IV). Results of gross examination and a description of each gastropexy site were recorded.

Microangiography was performed by isolating and catheterizing the celiac artery at the time of euthanasia. The hepatic and splenic arteries were ligated and the catheter flushed with heparinized saline (10 IU heparin/mL). The celiac artery was injected via a syringe with a radiopaque silicon rubber product (Microfil, FlowTek Inc, Boulder, CO) until the solution flowed into the gastric veins. After infusion, the entire gastropexy site, including the abdominal and gastric walls, was extirpated and placed in 7°C saline solution before microangiographic radiographs and tensile strength testing. Radiographs of the gastroperitoneal adhesion were made using a Faxitron radiographic machine (Faxitron Cabinet X-ray System, Hewlett Packard, McMinnville, OR) and high detail film (X-omat TL, Eastman Kodak Co, Atlanta, GA). Radiographic exposure was 30 kV(p) and 3 mA, with an exposure time of 12 seconds. Each gastropexy was evaluated for the presence of blood vessels within the seromuscular flap and vascular ingrowth from the flap to the body wall and a description was recorded.

After microangiography and within 8 hours of euthanasia, breaking strengths of each gastropexy site were determined using a universal testing machine (Instron Tension Analyzer Model 1122, Instron Corporation, Quincy, MA). A full-thickness section of stomach was placed in the top crosshead clamp and a full-thickness section of abdominal wall placed in the bottom crosshead clamp. Sandpaper was glued to the grasping surface of the crosshead clamps to minimize tissue slippage. Each distraction test was initiated at 0 N. Crosshead separation speed was 2.54 cm per minute. Data were collected over 240 seconds at a frequency of one sample per second on a 22.73 kg full scale load. Gastropexy failure was defined as the point of maximal tensile load.

Tissue samples from each gastropexy site were collected after distraction testing, fixed in formalin, and prepared for microscopic examination. All sections were stained with hematoxylin and eosin and Masson's trichrome, evaluated for amount and maturity of collagen, and a description recorded. No attempt was made to evaluate tissue sections for integrity or morphological detail because of previous distraction testing.

Data were entered using Dbase III Plus software and analyzed using Statistical Analysis System (SAS) software (version 6.03). All probabilities were generated by SAS. Differences in duration of surgery and maximum tensile load between the two groups were evaluated using a Student's t-test. A level of significance of $P < .05$ was used. Comparisons of postoperative morbidity, gross appearance, microangiographic appearance, and collagen amount and maturity were also made for each gastropexy technique.

RESULTS

There were no complications encountered during the surgical procedures or in the postoperative period. All dogs had an excellent appetite the day after surgery. No difference was observed between groups in attitude, rectal temperature, complete blood count, or creatinine kinase after surgery. Mild to moderate swelling of the seromuscular flap implantation site on the right abdominal wall was observed in 3 of 4 dogs from group 1, but had resolved by 7 days after surgery. Other than incision length, the remaining surgical wounds appeared similar between groups as evidenced by mild erythema which resolved by the seventh day after surgery. Body weight remained stable or increased for all dogs throughout the study.

The duration of surgery did not differ significantly between treatment groups ($P = .0813$). The mean duration of sugery was 69.75 ± 7.23 minutes for group 1 and 58.75 ± 7.63 minutes for group 2.

Each dog was evaluated 50 days after surgery by

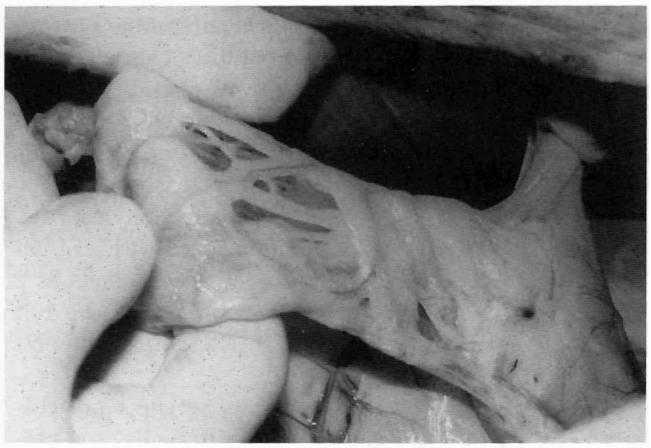

Fig 2. Anatomic appearance of a laparoscopic gastropexy 50 days after sugery. A pendulous adhesion suspended the stomach in normal anatomic position from the right abdominal wall. Omental adhesions were observed at the gastropexy site.

gross necropsy examination. A gastropexy was present in all dogs for both groups. Each gastropexy consisted of a dense adhesion. Omental adhesions were observed at the gastropexy site in all dogs but appeared more extensive in the dogs in group 1. Each stomach was maintained in its normal anatomic position within the abdomen by the gastropexy although the laparoscopic gastropexies were approximately 1 to 1.5 cm more pendulous and allowed more movement than the belt-loop gastropexies (Fig 2).

The microangiographic vasculature appeared similar between each group. Blood vessels were observed within the seromuscular flap in each dog in both groups. Slight vascular ingrowth from the stomach to the body wall was observed in 2 dogs, ie, 1 dog from each group. Blood vessels did not extend beyond the gastric tissues in the remaining dogs.

Maximum tensile load at failure did not significantly differ between treatment groups ($P = .0863$). The mean maximum tensile load was 76.55 ± 22.78 for group 1 and 109.21 ± 22.29 N for group 2. Failure occurred within the seromuscular flap in 6 of 8 gastropexies (75%). Failure at the adhesion site occurred in 2 of 8 gastropexies (25%), 1 dog from each group.

All of the gastropexies consisted of an adhesion composed of dense fibrous connective tissue on microscopic examination. Areas of skeletal muscle and smooth muscle were interposed by dense fibrous connective tissue. Small areas of smooth muscle disruption and mononuclear inflammation surrounded each suture. Numerous blood vessels consisting of capillaries and small arterioles were observed throughout each adhesion (Fig 3). The graft bed in group 1, in which the seromuscular flap was not reapposed, was covered by a thin layer of fibrous connective tissue. Underlying gastric submucosa and mucosa appeared microscopically normal. The graft bed in group 2 consisted of a thin layer of fibrous connective tissue where the seromuscular flap was reapposed. One gastropexy from group 2 contained an area of dense pyogranulomatous inflammation surrounding the suture tracts.

DISCUSSION

Numerous factors have been identified by retrospective analysis to be common to dogs developing GDV; however, the etiology is unknown.[21] Because of the high mortality associated with this disease, prophylactic gastropexy has been proposed for dogs which may be predisposed to develop GDV.[3,4] Properties of an ideal gastropexy include formation of a permanent adhesion between the stomach and the abdominal wall, absence of interference with normal gastric function, minimal postoperative management requirements, and a low frequency of complications.[22]

Laparoscopic surgery has become increasingly popular in humans since the development and wide acceptance of laparoscopic cholecystectomy.[23] A number of other procedures including appendectomy,[24] inguinal herniorrhaphy,[25] vagotomy,[26] and gastric fundoplication[27] are currently used or are being developed. Advantages of laparoscopic surgery over conventional surgery in humans include decreased postoperative pain, decreased expense, earlier return to work, and improved cosmetic appearance.[11,12]

Applicability of laparoscopic surgery may be limited in veterinary surgery due to the expense of laparoscopic equipment and specialized skills necessary for its use. Equipment required for laparoscopic gastropexy includes a laparoscope, a light source, a video monitor, an insufflator, and a few basic endosurgical instruments. The initial cost of this equipment is expensive; however, less expensive second hand equipment is often available from human hospitals as advancement of technology outdates current equipment. Veterinary hospitals performing endo-

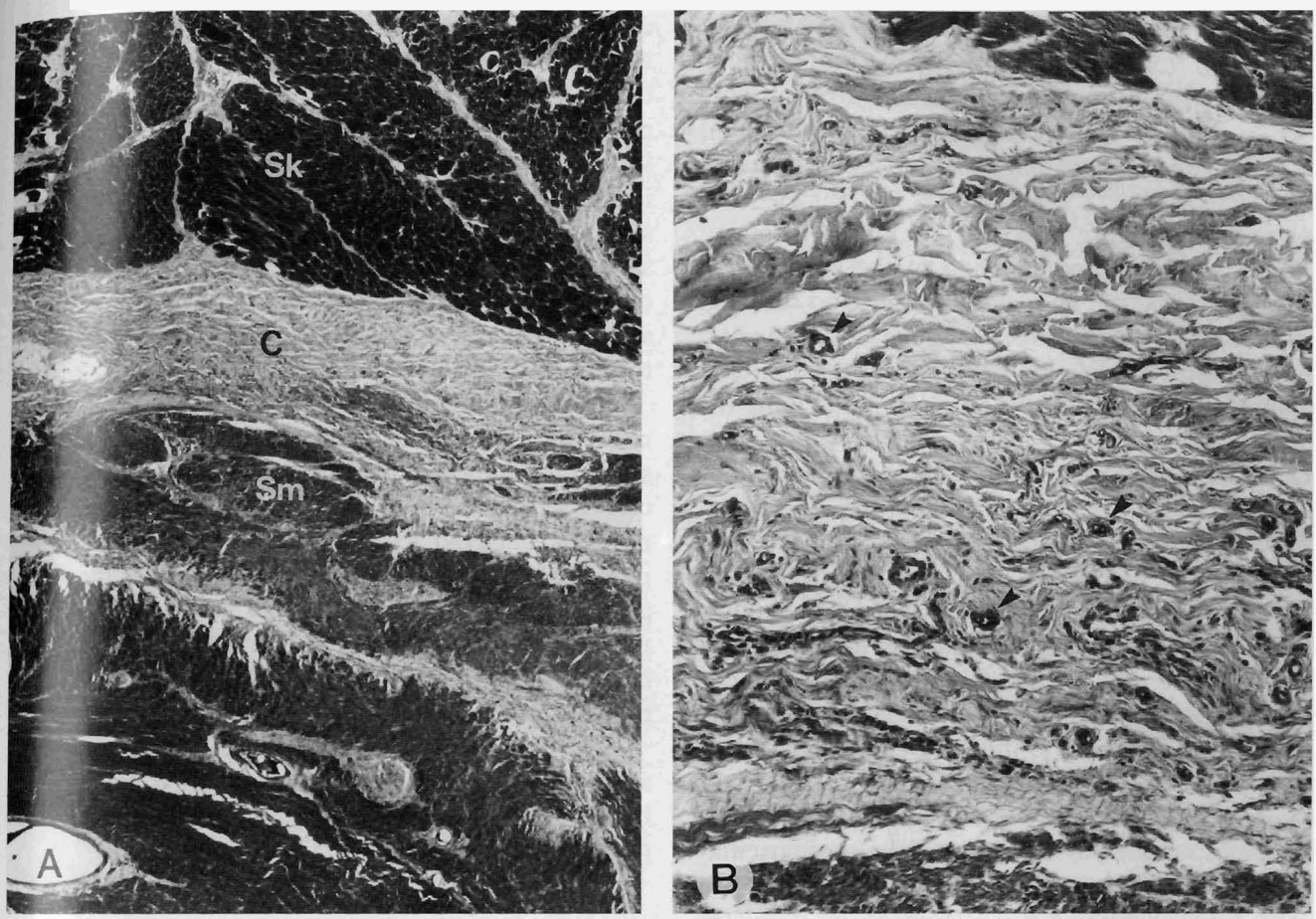

Fig 3. Photomicrograph of the adhesion created by laparoscopic gastropexy 50 days after surgery. (A) Skeletal muscle (Sk) and smooth muscle (Sm) were interposed by dense fibrous connective tissue (C). (Masson's trichrome stain; original magnification ×30.) (B) Mature fibroblasts and numerous capillaries and small arterioles (arrows) were observed within each adhesion. (Masson's trichrome stain; original magnification ×150.)

scopic and arthroscopic procedures already own much of specialized equipment required to perform many laparoscopic procedures. Elective laparoscopic gastropexy represents one of many applications of minimally invasive surgery for veterinarians with laparoscopic capabilities.

Recently, two minimally invasive techniques for prophylactic gastropexies using surgical stapling equipment have been described in dogs.[19,20] Surgical stapling equipment has evolved as a convenient alternative to sutures but may add significant additional expense to the procedure. This study was designed to compare an open versus an endosurgically created gastropexy using only basic endosurgical instruments. Compared with previous reports of stapled laparoscopic gastropexy, this technique required only a tissue grasper and curved dissection scissor.

Comparison of patient morbidity associated with laparoscopic and open abdominal procedures have not been reported in veterinary medicine. No difference in surgical morbidity could be detected between laparoscopic and open abdominal procedures in this study based on comparison of patient behavioral patterns, vital parameters, surgical wounds, complete blood count, or creatinine kinase. Elective abdominal surgery is associated with much less morbidity in canine patients compared with human patients; therefore, differences may be more difficult to detect. Assessment of more sensitive parameters such as serum epinephrine or cortisol levels may provide more insight into differences in postoperative morbidity.

Laparoscopic gastropexy did not require a significantly longer time than belt-loop gastropexy ($P > .05$) and the time required would lessen with addi-

tional experience. No procedural complications were observed in either group in this study. Complications reported in descriptions of minimally invasive gastropexy procedures include gastric perforation, splenic perforation, splenic puncture, and subcutaneous emphysema.[20] Complications associated with laparoscopic surgery may be minimized by using an open technique for insertion of the laparoscope cannula and abdominal insufflation instead of using blind insertion of a Verres cannula. Additionally, laparoscopic visualization before placing additional cannulas may help prevent trauma to underlying organs.

The effect of the pendulous gastroperitoneal adhesion observed in patients with laparoscopic gastropexy is unknown. The purpose of a gastropexy is to prevent major displacement of the pyloric antrum rather than complete immobilization. Other studies of right-sided gastropexy techniques have reported normal gastric motility and size on fluoroscopic examination suggesting no major physiological alterations.[4-6,28] Additionally, microvascular and microscopic evaluation of the gastropexy site did not reveal an abnormal effect on the gastric submucosa and mucosa caused by elevation of the seromuscular flap.

The force generated by a stomach as it dilates and twists and the tensile strength necessary for an effective gastropexy is unknown.[29,30] Levine reported biomechanical tensile strength of simple gastropexy, tube gastrostomy, and permanent gastropexy to be 38.06 N, 74.89 N, and 53.56 N, respectively 60 days after surgery.[29] In another study, Fox reported maximum tensile load at failure for circumcostal gastropexy, permanent gastropexy, and tube gastrostomy 50 days after surgery to be 56.90 N, 39.24 N, and 30.41 N, respectively.[30] The maximum tensile strength reported for circumcostal gastropexy was artifactually low because of tissue clamp failure while testing and accepted values are greater than 100 N.[30]

Biomechanical comparisons with a standard gastropexy technique (belt-loop gastropexy) were performed to permit comparison of the relative strength of adhesion formed by laparoscopic gastropexy and to allow inferences regarding its efficacy in preventing gastric torsion. The values obtained for biomechanical strength in this study were similar to previously reported values of biomechanical strength for accepted gastropexy techniques. No significant difference in biomechanical strength was detected between groups in this study ($P = .0863$, power = 0.57). The ability of this test to detect an actual difference in biomechanical strength between the study groups could have been improved by increasing the number of subjects in each group; however, sacrifice of additional animals was deemed unnecessary. Similarities between reported values and values obtained in this study lead us to believe that laparoscopic gastropexy creates an adhesion strong enough to prevent gastric volvulus.

Failure of the gastropexy occurred within the seromuscular flap in three patients from each group. The strength of adhesion obtained using either a circumcostal gastropexy or a belt-loop gastropexy technique is believed to be caused by healing of the previously elevated seromuscular flap rather than the adhesion.[30] Findings of this study would support the theory that the seromuscular flap rather than the adhesion site represents the weakest point of these gastropexy techniques.

The results of this study indicate that this laparoscopic gastropexy technique provides a minimally invasive alternative to prophylactic open abdominal gastropexy in dogs.

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