Temporary percutaneous T-fastener gastropexy and continuous decompressive gastrostomy in dogs with experimentally induced gastric dilatation

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OBJECTIVE
To evaluate a percutaneous, continuous gastric decompression technique for dogs involving a temporary T-fastener gastropexy and self-retaining decompression catheter.

ANIMALS
6 healthy male large-breed dogs.

PROCEDURES
Dogs were anesthetized and positioned in dorsal recumbency with slight left-lateral obliquity. The gastric lumen was insufflated endoscopically until tympany was evident. Three T-fasteners were placed percutaneously into the gastric lumen via the right lateral aspect of the abdomen, caudal to the 13th rib and lateral to the rectus abdominis muscle. Through the center of the T-fasteners, a 5F locking pigtail catheter was inserted into the gastric lumen and attached to a device measuring gas outflow and intragastric pressure. The stomach was insufflated to 23 mm Hg, air was allowed to passively drain from the catheter until intraluminal pressure reached 5 mm Hg for 3 cycles, and the catheter was removed. Dogs were hospitalized and monitored for 72 hours.

RESULTS
Mean ± SD catheter placement time was 3.3 ± 0.5 minutes. Mean intervals from catheter placement to a ≥ 50% decrease in intragastric pressure and to ≤ 6 mm Hg were 2.1 ± 1.3 minutes and 8.4 ± 5.1 minutes, respectively. After catheter removal, no gas or fluid leakage at the catheter site was visible.

CONCLUSIONS AND CLINICAL RELEVANCE
The described technique was performed rapidly and provided continuous gastric decompression with no evidence of postoperative leakage in healthy dogs. Investigation is warranted to evaluate its effectiveness in dogs with gastric dilatation-volvulus. (Am J Vet Res 2016;77:771–778)

Gastric dilatation-volvulus is a life-threatening medical and surgical emergency that most commonly affects large- to giant-breed, deep-chested dogs.1–4 The life-threatening nature of GDV is largely attributable to massive gastric distention, which compresses important abdominal vasculature, causing impaired blood flow to and from vital organs and consequently leading to hypovolemic shock, cardiac arrhythmia, electrolyte imbalance, and visceral necrosis, among other adverse effects.5–10 Gastric volvulus without dilatation results in minimal visceral damage even after 12 hours, highlighting its negligible contribution to the pathological changes caused by GDV.9 As such, rapid gastric decompression and stabilization are critical in the treatment of dogs with GDV to restore venous return and halt progression of systemic decompensation.8,10

Often, gastric dilatation can exist for a prolonged period when affected dogs must be transported from a general veterinary practice to an emergency facility or must await corrective surgery at a specialty center. Trocarization and oroagastic tube placement reportedly achieve successful decompression 86% and 76% of the time, respectively.11 However, this effect is only temporary, and clinically, gastric distention can recur in minutes, along with the associated adverse sequelae. Gastrostomy performed in anesthetized dogs via a 5-cm incision in the right paracostal region reportedly provides lasting gastric decompression.12 Although this method facilitates continuous decompression, it is also invasive and requires an additional closure at corrective surgery. Consequently, this decompressive technique is typically considered only when surgery is to take place after considerable delay.

A prolonged interval from onset of clinical signs of GDV to evaluation at a surgical facility has been shown to be associated with a poor prognosis in some studies,13,14 while having no effect in other studies.15,16

ABBREVIATIONS
GDV Gastric dilatation-volvulus
IGP Intragastric pressure
IGV Intragastric volume
TTG Temporary T-fastener gastropexy

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This conflicting evidence may be challenging to interpret because limitations and confounding factors are common in many veterinary studies such as those involving owner recall. More likely, prognosis is related to the timing and severity of cardiopulmonary and vascular compromise, which may be directly related to the degree and duration of gastric dilatation. It is therefore logical to presume that reducing the duration and severity of gastric dilatation in dogs should improve gastric perfusion and cardiopulmonary homeostasis and facilitate preoperative stabilization, as has been demonstrated.\textsuperscript{8,17,18} An ideal technique for treatment of severe gastric dilatation would be minimally invasive and quick to perform and would provide rapid, effective, continuous gastric decompression.

The T-fastener is a device used in human interventional radiology and minimally invasive surgery to allow temporary fixation of an organ, most often to facilitate tube placement into the stomach or small intestine, either for feeding\textsuperscript{19,20} or decompression.\textsuperscript{21} T-fasteners consist of a suture attached to a metal T-bar, which is loaded into a slotted needle that is introduced percutaneously into the organ lumen and deployed. The deployed needle is removed, and the suture and attached intraluminal T-bar remain and are used to affix the organ to the body wall. Temporary fixation with a T-fastener allows for immediate dilatation of a stoma tract or direct percutaneous insertion of a catheter or tube into a lumen, prevents early leakage at the site of the surgical opening, reduces the risk of tube dislodgment, and facilitates tube replacement.\textsuperscript{22,23} To the authors’ knowledge, use of T-fasteners in veterinary medicine has not been reported, although use of an experimental endoscopic prototype has been reported for gastrostomy closure in dogs undergoing natural orifice transluminal endoscopic surgery.\textsuperscript{24}

The purpose of the study reported here was to describe a novel means of gastric decompression in dogs with experimentally induced gastric dilatation by use of a percutaneously placed TTG and self-retaining gastrostomy catheter, evaluate the efficacy of this technique, and determine whether the resulting gastrostomy wound would leak following removal. We hypothesized that the technique would be feasible and quick to perform, would effectively and continuously decompress the stomach, and would result in no gastrostomy wound leakage.

Materials and Methods

Dogs

Six clinically normal sexually intact large-breed dogs at risk for GDV and weighing at least 15 kg were included in the study. Dogs had been obtained from a local rescue group and were enrolled after informed consent was obtained. All dogs received a preoperative physical examination, measurement of PCV and serum total protein concentration, and blood gas analysis. The study protocol was approved by the University of Florida Veterinary Hospitals Research Review Committee and the Institutional Animal Care and Use Committee (protocol No. 201408149).

Experimental procedure

In preparation for the procedure, all dogs received dexmedetomidine (5 µg/kg) and hydromorphone (0.1 mg/kg) administered IV or IM. Anesthesia was induced with propofol (≤ 4 mg/kg, IV), administered to effect, and maintained with isoflurane in 100% oxygen administered via an endotracheal tube that was connected to a rebreathing circuit. A ventilator was used to maintain capnometric readings within 35 and 45 mm Hg. Dogs were monitored with continuous ECG, capnography, and direct arterial blood pressure assessment. Crystalloid fluid (10 mL/kg/h) was administered IV for the duration of anesthesia. Dogs were positioned in dorsal recumbency with slight leftward obliquity. The abdomen and caudal aspect of the thorax were clipped of hair and aseptically prepared by use of chlorhexidine and sterile saline (0.9% NaCl) solution.

Surgical drapes were applied for an abdominal surgical approach. The stomach was approached endoscopically, insufflated with room air, and evaluated for any abnormalities. Following initial gastroscopy, gastric insufflation was continued until moderate outward tympany was evident and rugal folds were no longer visible endoscopically. Once this was achieved, the TTG and gastrostomy catheter supplies were readied (Figure 1).

The procedure was then performed as follows and timed from placement of the first T-fastener to locking of the pigtail catheter (Figure 2; Supplemental Video S1, available at http://avmajournals.avma.org/doi/suppl/10.2460/ajvr.77.7.771). Three T-fasteners\textsuperscript{a} were placed percutaneously approximately 1.5 cm apart in a triangular orientation, into the gastric lumen via the right lateral aspect of the abdomen, and 1 to 3 cm caudal to the 13th rib and lateral to the rectus abdominis muscle. The exact location of placement within this region was determined by the degree of palpable tympany and confirmed via endoscopy. During placement, all T-fasteners were attached to a 6-mL syringe containing 2 mL of sterile saline solution. After the T-fasteners were placed into the gastric lumen, the syringe plunger was drawn back until bubbles were noticed, indicating intragastric positioning.

In the center of the triangle formed by the T-fasteners, a 21-gauge needle was inserted into the gastric lumen. A 0.018-inch, 60-cm guidewire was introduced through the needle, then the needle was removed over the guidewire. A 5F introducer\textsuperscript{b} was placed over the guidewire to dilate the tract, after which the introducer was removed. A 5F locking pigtail catheter\textsuperscript{c} was placed over the guidewire into the gastric lumen, the guidewire was removed, and the pigtail coil was formed, locked in place, and retracted to the body wall. The catheter was attached to a device\textsuperscript{d} used to measure and record gas outflow from the catheter and IGP, which had been calibrated in accordance with...
The endoscopic unit was then used to insufflate the stomach to a pressure of 23 mm Hg. Once that pressure was reached, insufflation was discontinued and air in the stomach was allowed to passively drain from the catheter until intraluminal pressure reached 5 mm Hg. Time and flow were measured continuously, and intraluminal pressure measurements were obtained every 30 seconds. This process was performed 3 times, consecutively, in each dog. Upon completion of the third round, the pigtail catheter was unlocked and removed, and the anchor suture of each T-fastener was cut externally, allowing the fastener bar to remain in the gastric lumen.

A multitrocar laparoscopy port was placed 1 cm caudal to the umbilicus on midline. An insufflation unit was used to achieve capnoperitoneum and bring the intra-abdominal pressure to 8 to 10 mm Hg. Afterward, a 5-mm 0° laparoscope was introduced into the abdomen via the multitrocar port. A laparoscopic blunt probe was used to manipulate the stomach and facilitate laparoscopic and endoscopic evaluation of the catheter and T-fastener gastric wounds. The stomach was insufflated until rugae were no longer visible and the gastrostomy site could be observed endoscopically. Concurrently, the serosal surface was examined laparoscopically to identify any evidence of leakage (gas bubbles or fluid egress). Additionally, the location of TTG and gastrostomy catheter placement into the stomach was recorded.

After the procedure was complete, a second 5-mm laparoscopic port was placed midway between the xiphoid and umbilicus. Laparoscopic, intracorporeal gastropexy was performed with 2-0 knotless barbed suture, and dogs were castrated routinely. Upon completion of the gastropexy, the site was evaluated endoscopically for the presence of any intraluminal suture material. Dogs were hospitalized and monitored for 72 hours to identify any complications related to the procedure.

**Statistical analysis**

Statistical software was used for all data analysis. Continuous parametric data are reported as mean ± SD and range. Total IGV was defined as the total gas outflow between 23 and 5 mm Hg. The IGP data were analyzed from 23 to 6 mm Hg. Change in IGV at 1 minute after catheter placement and duration of the interval from catheter placement to achieving a 50% decrease in IGP were calculated.

**Results**

**Animals**

All 6 dogs completed the study. Breeds included 1 each of Great Dane, Golden Retriever, German Shepherd Dog, Doberman Pinscher, hound mix, and pit bull-type mix. Mean ± SD age was 25.5 ± 18.2 months (range, 9 to 48 months), and mean body weight was 27.7 ± 16.5 kg (range, 16.2 to 60 kg). Findings of physical examination, PCV and serum total protein concentration measurement, and preoperative venous blood gas analysis were unremarkable for all dogs.
Experimental procedure

Mean catheter placement time was 3.3 ± 0.5 minutes (range, 2.6 to 3.9 minutes). Mean interval from catheter placement to achieving a ≥ 50% reduction in IGP was 2.1 ± 1.3 minutes (range, 1.0 to 6.0 minutes) and to achieving an IGP ≤ 6 mm Hg was 8.4 ± 5.1 minutes (range, 3.5 to 19.5 minutes; Figure 3). Mean percentage decrease in IGV after 1 minute of decompression was 28 ± 12% (range, 8% to 43%). Mean interval from catheter placement to achieving a ≥ 50% decrease in IGV was 3.2 ± 2.3 minutes (range, 1.5 to 8.0 minutes; Figure 4).

In 1 dog, endoscopic examination revealed that the gastric mucosa had become cyanotic after insufflation to an unknown pressure during initial creation of a tympanic state. The first round of decompression testing was aborted in this dog because of concern for it after an approximately 60% decrease in IGP yielded only mild to moderate improvement of the mucosa. The stomach was manually evacuated of air through the catheter by use of a 35-mL syringe and monitored endoscopically. Once a healthy mucosal appearance had been restored, the second and third insufflation-decompression treatments were performed routinely.

In all dogs, no evidence of gas or fluid leakage at the catheter site was visible laparoscopically or endoscopically after catheter removal. In 5 dogs, the T-fastener and...
catheter require a total 2 catheter were placed 26–28 typically identified in dogs with GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was chosen on the basis of those data occurring GDV. The maximum IGP of 23 mm Hg in the present study was choose...
In interventional radiology and minimally invasive surgery to facilitate gastrostomy tube placement for feeding or decompression, \textsuperscript{20,30} T-fastener gastropexy and gastrostomy catheters are used to allow for controlled dilatation of a stoma tract, facilitating direct percutaneous insertion of a tube into the lumen, reducing the risk of tube dislodgement, and allowing easy tube replacement. \textsuperscript{22,25} A clinical study \textsuperscript{39} involving comparison of percutaneous radiologic gastrostomy tubes placed with or without T-fasteners revealed that T-fasteners greatly reduce the chance of serious technical complications. Complications related to the T-fasteners themselves are seldom reported and are typically limited to skin irritation with uncommon instances of infection and fistula formation. \textsuperscript{31} These complications are associated with T-fasteners left in place for 1 to 2 weeks and would be unlikely to develop with the short duration of use expected as in the procedure reported here. \textsuperscript{32} To the authors’ knowledge, the present study represents the first reported use of T-fasteners in veterinary medicine to achieve temporary gastropexy. This technique could be adapted in veterinary medicine to allow placement of larger, permanent gastrostomy or jejunostomy feeding tubes as is performed in human medicine. \textsuperscript{20,53,54}

In addition to the TTG, success of the technique reported here was attributable in part to the properties of the decompressive catheter used. The device chosen was a 5F catheter with a locking 10-mm pigtail containing 5 drainage holes within the pigtail loop. The orientation of the fenestrations within the loop prevents or limits the chance that the catheter will become obstructed from contact with the mucosa or intraluminal material. Additionally, the self-locking pigtail aids in preventing catheter pull-out and obviates the need for a finger-trap suture. The size of the catheter was chosen with the goal of allowing adequate gastric decompression without creating a considerable gastric wound. Use of a ≤14-gauge needle or catheter has been recommended for trocarization and decompression in dogs with GDV, without any reported leakage of gastric contents. \textsuperscript{11,35} A 14-gauge needle and 5F catheter have outer diameters of 21 mm and 17 mm, respectively, but the catheter used in the present study is placed by dilatation of tissue in contrast to cutting, which is typical of a hypodermic needle. Consequently, leakage at the catheter site was believed to be unlikely and was not observed in any dog.

The 5F catheter used in the study reported here could not be used to remove solid contents from the gastric lumen. With the exception of a food-associated bloat progressing to volvulus, this limitation would be unimportant given that the increasing gaseous distention with no outlet is responsible for deleterious systemic effects in dogs with GDV. \textsuperscript{55} If an affected dog was positioned in sternal or left lateral recumbency, the catheter placement technique we used would facilitate removal of gas because gas would rise to the site of the catheter as occurs with typical intermittent trocarization. Additionally, the technique does not need to be exclusive. The TTG and gastrostomy catheter could be used to establish continuous gas outflow, and subsequently, an orogastric tube could be passed to remove solid material. Some clinicians routinely perform trocarization prior to placing an orogastric tube to facilitate tube passage through the lower esophageal sphincter. Food had been withheld from the dogs of the present study prior to the procedure, so we are unable comment on how well the catheter could be expected to function with gastric material obstructing its lumen. However, the catheter appeared (endoscopically) a few times to be covered with mucus and flow rates declined. This problem was easily remediated with a 6-mL flush with saline solution followed by 6 mL of air. In dogs with clinical GDV, it may be beneficial to flush the catheter intermittently or whenever obstruction is suspected.

Evidence suggests that the most devastating component of GDV is gastric dilatation because it is primarily responsible for initiating a cascade of adverse sequelae. Portal and caval compression, decreased venous return and cardiac output, hypoxemia, gastrointestinal edema, gastric hypertension and ischemia, and release of myocardial depressant factors and systemic inflammatory mediators all occur secondary to severe gastric dilatation. \textsuperscript{11,36,37} Without gastric dilatation and associated vascular compression, gastric pathological effects appear to be limited, as demonstrated in a study \textsuperscript{9} in which 360° gastric volvulus was experimentally induced in dogs while maintaining gastric decompression. In that study, \textsuperscript{9} all other viscera drained via the portal system were histologically unremarkable, even after 12 hours of volvulus. Additionally, only mild to moderate changes to the stomach were identified after the procedure and appeared to be reversible given that gastric tissue was reported to be histologically unremarkable 7 days after surgery. Investigators in other studies \textsuperscript{11,17,18} have demonstrated that cardio-pulmonary variables improve rapidly following gastric decompression. Therefore, achieving and maintaining decompression in dogs with clinical GDV should reduce the adverse impact of extreme gastric dilatation, improving patient stabilization and possibly overall outcome.

Measurements of IGP were standardized among dogs in the present study, starting at 23 mm Hg and ending at 5 mm Hg, whereas total IGV was variable among dogs because of their differing sizes. For this reason, IGP data were analyzed so that they could be compared directly and IGV data were analyzed as a percentage change to allow direct comparison of volume data among dogs. The change in IGP after catheter placement was rapid, with a 50% decrease (to 11.5 mm Hg) identified in the first 2 minutes (Figure 3). As expected, changes in IGV followed the same pattern as changes in IGP (Figure 4), with more rapid gas outflow from the catheter occurring with higher IGPs. Mean interval from catheter placement to a 50% reduction in IGV was approximately 3.5 minutes. The
remaining 50% of the IGV of gas exited the catheter at a much slower rate. It is important to consider that gas exited passively, and when gas efflux slowed, a reduction in the remaining IGV could be facilitated manually by use of a large syringe, as was performed in 1 dog, or potentially a suction unit. It is possible that a small amount of gas escaped via the lower esophageal sphincter or pylorus into the duodenum during the procedure, confounding interpretation of changes in IGP and IGV. If this occurred, we believe it was of minimal consequence because the pressure could be held at 23 mm Hg when the catheter was occluded, which would not have been possible if gas was exiting the stomach. In addition, no audible gas efflux from the esophagus was noticed during data collection, gas flow through the catheter was continuously recorded, and lastly, the small intestine did not appear gas distended during laparoscopic evaluation.

In the present study, no major complications were associated with placement of the TTG and gastrostomy catheter during the procedure or in the 72 hours afterward. One minor complication for 3 dogs was a 1- to 2-mm remnant of Fastener suture that was identified laparoscopically to be coming through the gastric serosa (Figure 5). This would likely not cause a long-term problem, given that absorbable suture material was used, and when suture is removed in humans 1 to 2 weeks after placement, complications are seldom. In 1 dog during initial insufflation to achieve tympany at an unknown pressure, the gastric mucosa appeared cyanotic. Out of concern for that dog, after an approximately 60% passive decrease in IGP was achieved, the remaining IGV of gas was removed quickly by use of a 35-ml syringe attached to the catheter. Decompression was maintained until the mucosa appeared grossly normal again. Because the pressure transducer could not be attached prior to catheter placement, the total IGP achieved in the dog was unclear. However this example demonstrated that after the initial rapid passive decompression occurs, the remainder of the IGV could be removed manually if desired.

Interestingly, whereas all catheters were placed in the right side of the stomach, all catheter entry sites in 5 of the 6 dogs were at the margin of the fundus and gastric body in the ventral surface. This suggested that with dilatation alone, the body and fundus were displaced ventrally and to the right, which is counter to what would be expected in dogs with clinical GDV. This finding may have been attributable to the rapid rate of gastric dilatation or perhaps to the fact that dilatation was induced with the dogs in dorsal recumbency.

In the present study, placement of a TTG and decompressive gastric catheter was achieved rapidly and successfully and provided effective continuous gastric decompression in dogs with experimentally induced gastric dilatation, without causing a clinically important gastric wound. This technique may be an effective method for sustained gastric decompression in dogs with naturally occurring GDV; however, clinical investigation is required.

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Footnotes
a. SAF-T-PEXY, Kimberly Clark Medical, Roswell, Ga.
b. Mallinckrodt modification micropuncture introducer set, Cooke Medical, Bloomington, Ind.
c. Dawson-Mueller multipurpose drainage catheter, Cooke Medical, Bloomington, Ind.
d. Labquest 2 with gas pressure sensor and spirometer, Vernier Software & Technology, Beaverton, Ore.
e. SILS Port, Covidien Ltd, Minneapolis, Minn.
f. VLOC 90, Covidien Ltd, Minneapolis, Minn.
g. JMP version 9.0.2, SAS Institute Inc, Cary, NC.

References


