Laparoscopic Gastropexy as a Preventative Measure for Gastric Dilation Volvulus in Canines

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ABSTRACT

Gastric Dilation Volvulus (GDV) is a fatal condition in canines especially those that are large or giant breeds. GDV results from the stomach distending and twisting on itself which when left untreated causes shock and ultimately death. The only method of prevention for GDV is a gastropexy, a surgical procedure that sutures the stomach to the abdominal wall to prevent volvulus or twisting. This paper specifically looks at the use of laparascopy in canine gastropexy surgery. Laparascopy is a standard in human medicine, however is not as commonly used in veterinary medicine. While laparoscopic-assisted gastropexy (LAG) techniques are being used in select veterinary clinics today, total laparoscopic gastropexy (TLG) techniques are just starting to be researched. LAG and TLG techniques are compared with each other and with traditional open surgery. The benefits that minimally invasive laparoscopic techniques provide should be considered when thinking about gastropexy as a preventative measure for GDV.
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INTRODUCTION

Gastric Dilatation-Volvulus or GDV is a life threatening condition in canines that involves the enlargement (dilatation) and twisting (volvulus) of the stomach. There are about 60,000 cases of GDV, also known as bloat or gastric torsion, per year with mortality rates of 10% to 60% for dogs that receive treatment (Steelman-Szymeczek et al, 2003). Furthermore there is an 80% reoccurrence rate of gastric dilatation-volvulus (Whitney, 1989) and GDV has been reported to reoccur in dogs up to five times (Ellison, 1993). Unfortunately, the exact cause of GDV is unknown, however gastropexy, a surgical procedure that fixes the stomach to the abdominal wall, is a preventative measure for this disease. Gastropexy is often done when a dog presents symptoms of GDV to avoid reoccurrence, but a gastropexy can also be performed before a canine develops gastric dilatation-volvulus. This is recommended for dogs that are at high risk for bloating- typically large, deep-chested breeds. It has been reported that the reoccurrence of GDV drops to 4.3% after a dog receives a gastropexy (Mayhew and Brown, 2009). Additionally, there has never been a report of GDV in a dog that received a prophylactic gastropexy (Robbins, 2009).

There are many different gastropexy techniques, however, the four most commonly used gastropexies in Northern America fix the gastric antrum to the right abdominal wall. These include incisional, belt loop, tube, and circumcostal gastropexy, which have all demonstrated the ability to form permanent attachment of the stomach to the abdominal wall. Each of these different gastropexy procedures has associated advantages and disadvantages. The different gastropexy techniques have all have been shown to decrease the rate of GDV reoccurrence, however, there has been no controlled
study comparing the adhesion strength, mortality, morbidity, and complication rates of
the different types (Watson and Tobias, 2006). It has therefore been suggested that the
veterinarian use the surgery technique he or she is most comfortable with.

As with any surgery there is an interest in finding the least invasive procedure
possible since that also means it is less painful and there is a quicker recovery time. The
use of laparoscopic assistance in gastropexies is gaining popularity in the veterinary field
because it is minimally invasive. Larpascopy is a tool that became a standard in human
care in the 1990’s (Salmeri, 2006) and is expected to become a standard in animal care as
well. Laparoscopy provides a valuable diagnostic tool as well as surgical aid by utilizing
a laparoscope, an instrument that enables internal viewing. Currently, laparoscopic-
assisted surgeries are being performed in some veterinary clinics but total-laparoscopic
surgery has not yet been embraced. Mayhew and Brown (2009) suggest that
intracorporeal suturing techniques that are used in human surgery may be adapted for
veterinary medicine allowing surgery such as a gastropexy to be done entirely
laparoscopically. In this paper, laparoscopic-assisted gastropexy and total laparoscopic
gastropexy techniques are compared to the open surgery as well as to each other. Each
technique has advantages and disadvantages and in the long run any gastropexy is
arguably preferable than none for dogs with a high-risk for GDV.
With GDV, which is also known as bloat or gastric torsion, the stomach rotates on the mesenteric axis blocking off the esophageal and the pyloric passages. The anatomy of the canine stomach can be seen in Figure 1. It is believed that dilation precedes volvulus however there have been some reports of volvulus occurring without the presence of dilatation (Broome and Walsh, 2003). Regardless of which comes first, GDV occurs when the obstruction caused by the rotation hinders material from entering and exiting the stomach. As digestion continues the stomach distends or bloats. This is deadly if left untreated and canine volvulus rarely corrects itself, requiring surgical repositioning of the stomach.

The sequence of events that lead to GDV are seen in Figure 2. The stomach can rotate anywhere from 90 to 360 degrees but rotates 270 degrees clockwise (from a caudal or surgeon’s view, see Figure 3) in most cases (Fossum et al., 2002). The pylorus is displaced to the front and left of the midline of the stomach and the fundus (the upper left portion of the stomach) moves to the front and right causing the clockwise rotation.

GDV causes many serious issues in canines which accounts for why bloat is associated with such a high mortality rate. Shock, organ failure, and bleeding disorders all result from GDV. The pressure from the stomach leads to inadequate tissue perfusion or nutrition which causes portions of the abdominal wall to die. Torsion can also cause necrosis of the stomach wall if it tears the arteries between the spleen and stomach. The pressure the stomach exerts has serious systemic effects, harming not just the stomach but the kidneys, heart, small intestine, and pancreas as well. The heart in particular is
Figure 1. Anatomy of the canine stomach (*Aspinall and Cappello, 2009*).
Figure 2. Sequence of events that lead to GDV in canines (*Hill’s Pet Products, 1989*).
Figure 3. Clockwise rotation of the stomach in GDV (Fossum et al, 2002).
affected from the reduced blood flow through the caudal vena cava and portal vein which causes shock and myocardial ischemia. Myocardial ischemia is a lack of oxygen-rich blood in the heart muscle that causes pain and increases the likelihood of heart attack. Cardiac arrhythmia or irregular heartbeats also often occur and the resulting lack of blood flow to the kidneys may cause kidney failure. Breathing becomes increasingly difficult for a dog with GDV since the bloated stomach overwhelms the diaphragm. Frequently, torsion of the spleen coincides with torsion of the stomach and leads to blood clots. Canines with GDV may also develop a bleeding disorder called DIC, disseminated intravascular coagulation. Organs can become engorged with blood leading to bacterial infection and the release of endotoxins into the bloodstream. If left untreated, GDV will cause multiple organ failure and stomach rupture (Rawlings, 2002b).

The actual cause of bloat is unknown. Eating large amounts of food or drinking large amounts of water rapidly, eating out of an elevated bowl, and intense exercise right after a meal are all believed to increase the risk of GDV in a dog (Rawlings, 2002b). This is due to the aerophagia, or the swallowing of too much air resulting from these activities. There have been many theories of what increases the risk of GDV. It had previously been believed that large amounts of soy or cereal in dry dog food increased the risk of GDV in canines; however, a study done by Raghavan and colleagues (2006) found this to be false. Their study interestingly showed that large amounts of fat and oil in dry dog food lead to a 2.4 fold increase in risk for GDV. Temperament, breed, genetics, age, and sex can also affect the risk of a dog developing GDV (Levine and Moore, 2009). A study of 1,934 dogs with GDV and 3,868 randomly selected control dogs, found that Great Danes, Weimaraners, Saint Bernards, Gordon Setters, and Irish Setters have the highest
risk for GDV. Additionally, it was found that purebred dogs have a higher risk for GDV than mixed-breeds (Glickman et al, 1994). This study also saw that increased age is associated with the development of GDV. In a later study, Glickman and colleagues (1997) found that male gender, being underweight, and excitable, nervous or fearful temperament are predisposition factors for GDV. It has also been found that a high thoracic depth-to-width ratio and genetics are connected to this condition (Schellenberg et al, 1998).

Typically only large or giant breed canines are affected by gastric dilatation-volvulus. According to Rawlings and colleagues, “Large-(Akita, Bloodhound, Collie, Irish Setter, Rottweiler, Standard Poodle, and Weimaraner) and giant-breed (Great Dane, Irish Wolfhound, Newfoundland, and Saint Bernard) dogs were shown to have a 6 % incidence of GDV, with GDV accounting for 16% of all the deaths in these breeds” (2002). The overall risk of GDV is 0.29-0.68 % (Glickman et al, 1994). Taking into account the likelihood of GDV, the lifetime expectancy and the cost of prophylactic gastropexy versus treatment of GDV in several high-risk breeds (Table I.), Ward and his colleagues highly recommended prophylactic gastropexy surgery for these breeds (2003). Interestingly, military dogs are also at higher risk for GDV. In a study of 927 military dogs, 9.1% developed GDV. This is believed to be associated to breed as well as a stressful working situation (Rawlings and Mahaffey, 2002). Additionally, there are also some studies being done relating weather, in particular atmospheric pressure and temperature, to GDV (Levine and Moore, 2009).

While there are certain actions that may help prevent GDV it is still important to recognize this disease as soon as possible after its onset. Immediate medical attention is
Table I. Lifetime risk of GDV and life expectancy based on breed (Ward et al, 2003).

<table>
<thead>
<tr>
<th>Breed</th>
<th>Median life expectancy(^a)</th>
<th>Annual GDV incidence(^b)</th>
<th>GDV lifetime risk</th>
<th>GDV lifetime mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Years</td>
<td>(N)</td>
<td>%</td>
<td>(N)</td>
</tr>
<tr>
<td>Great Dane</td>
<td>8.4</td>
<td>44</td>
<td>5.3</td>
<td>211</td>
</tr>
<tr>
<td>Irish Setter</td>
<td>11.8</td>
<td>20</td>
<td>2.4</td>
<td>256</td>
</tr>
<tr>
<td>Rottweiler</td>
<td>9.8</td>
<td>101</td>
<td>0.4</td>
<td>117</td>
</tr>
<tr>
<td>Standard Poodle</td>
<td>12.0</td>
<td>23</td>
<td>2.4</td>
<td>132</td>
</tr>
<tr>
<td>Weimaraner</td>
<td>10.0</td>
<td>21</td>
<td>2.1</td>
<td>96</td>
</tr>
</tbody>
</table>
essential to the canine’s survival. Signs of GDV include excessive salvation, restlessness, and abdominal pain. A distended abdomen and unsuccessful attempts to vomit also are indications. Later and more severe signs of GDV consist of pale gum color, shock, weakness and collapse (Rawlings, 2002). Often times diagnosing GDV in a canine is pretty straight forward. However, if it is difficult to obtain a definitive diagnosis, radiographs of the right lateral view should be used. The presence of air in the peritoneal cavity, the space between the abdominal wall and the abdominal cavity suggests GDV (Whitney, 1989). A radiograph of a dog with GDV can be seen in Figure 4. GDV is typically seen in large and giant breed canines rather than smaller breed dogs. Therefore, if a small dog, a dog that is not large or giant-breed, presents with signs characteristic of GDV, a tumor, aerophagia due to pneumonia or congestive heart failure should be ruled out first (Whitney, 1989).

In treatment of this condition it is important to stabilize the dog before surgically repositioning the stomach. This includes treatment for shock with IV, intravenous, fluids and decompression or deflation of the stomach either through trocharization of the abdominal wall with suction or intubation. At this point surgery can be performed to reposition the stomach and check abdominal tissue for viability, or ability to survive. Tissue viability or health is generally determined by color. Grey-green and black tissue is most likely dead tissue and should be invaginated or removed (resectioned). Non-viable tissue is found in about 10% of GDV cases and is coupled with a higher mortality rate of 56% when rupture was not present (Whitney, 1989). In cases where invagination or resection of tissue is required, euthanasia is often recommended for the owner to consider
Figure 4. Radiograph in left lateral view of a canine with GDV before decompression. (Robbins, 2009).
due to the increased probability of death. Another complication in GDV can be if the spleen is twisted in which case splenectomy or removal of the spleen is necessary.

A gastropexy is typically performed in dogs with GDV once the stomach is repositioned and the abdominal region is checked for viability. As mentioned previously, GDV has a high reoccurrence rate and a gastropexy is the only preventative measure for gastric dilatation-volvulus. Prophylactic or preventative gastropexy will be discussed in greater detail later in this paper. Postponement of stomach derotation and gastropexy for days or even weeks after treatment for GDV was at one time promoted in veterinary medicine while veterinarians tried to determine if the bloat was due to simple gastric dilatation or torsion. Simple gastric dilation is not a surgical emergency whereas gastric torsion is. With new research, however, practitioners now suggest that derotation and gastropexy be done right after decompression of the stomach since delaying surgery caused the mortality rate to increase significantly (Ellison, 1993).

After surgery there are still many complications that can occur. It has been found that most post-surgical death occurs within four days of the surgery (Whitney, 1989). Table II shows problems known to arise after surgical treatment of GDV. It is necessary to monitor the dog closely post-surgery especially for cardiac arrhythmias which occur in 50% of GDV cases typically 12-36 hours after development of GDV (Whitney, 1989).
Table II. Potential complications in GDV dogs post surgery (*Whitney, 1989*).

<table>
<thead>
<tr>
<th>Potential Complications</th>
<th>Complications Post Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular arrhythmias</td>
<td>Vomiting</td>
</tr>
<tr>
<td>Shock</td>
<td>Hypokalemia</td>
</tr>
<tr>
<td>Endotoxemia/sepsis</td>
<td>Acid base disturbance</td>
</tr>
<tr>
<td>Progression of gastric necrosis</td>
<td>Pneumothorax</td>
</tr>
<tr>
<td>Gastric rupture</td>
<td>Gastric atony</td>
</tr>
<tr>
<td>Peritonitis</td>
<td>Recurrent dilation/volvulus</td>
</tr>
<tr>
<td>Hypoproteinemia</td>
<td>Incisional infections/dehiscence</td>
</tr>
<tr>
<td>Blood loss anemia</td>
<td>Pancreatitis</td>
</tr>
<tr>
<td>Melena</td>
<td>Renal failure</td>
</tr>
<tr>
<td>Bronchopneumonia</td>
<td>Disseminated intravascular coagulopathy</td>
</tr>
<tr>
<td>Pulmonary abcessation</td>
<td>Intestinal intusseption</td>
</tr>
<tr>
<td>Hepatopathies</td>
<td>Intestinal volvulus</td>
</tr>
<tr>
<td>Hemorrhagic gastritis</td>
<td>Fever of unknown origin</td>
</tr>
</tbody>
</table>
PREVENTION OF GDV

Non-Surgical Prevention of GDV

While gastropexy is considered to be the only true preventative measure for GDV, veterinarians suggest several methods that may help reduce a dog’s chance of presenting with gastric torsion. These suggestions go hand in hand with the behaviors that increase the risk of GDV such as eating habits and timing. Feeding dogs smaller meals more often, removing access to water right before food, avoiding exercise before and after meals, and not using elevated feeding dishes should be considered if a dog is predisposed to GDV. Avoiding a diet with fat and oil in the first four ingredients may also help reduce the chance of developing GDV (Raghavan et al, 2006). Other theories exist linking content of food, size of food kibbles, and citric acid contents with this condition but these remain unproven at this time.

Surgical Prevention of GDV

While gastropexy surgery cannot fully prevent dilatation of the stomach, it does significantly decrease the occurrence of GDV since the stomach is unable to volvulus or twist. The non-surgical prevention suggestions may help reduce the risk of GDV but will not stop GDV from developing in dogs. Therefore it is stressed that dogs predisposed to GDV have a gastropexy performed, especially military dogs as to prevent the loss of valuable trained working dogs (Rawlings and Mahaffey, 2002). These high risk dogs include the breeds in Table I., especially if they are young male dogs. Bloat is the number
one cause of death in several large and giant breed canines and 30% of dogs displaying
gastric dilatation die or are euthanized. Prophylactic gastropexy is also cost effective
since gastropexy costs about $400 compared to treatment of GDV which is
approximately $1500 (Ward et al, 2003) and can be a recurring cost.
TYPES OF GASTROPEXY

Funkquist first suggested the gastropexy or fundic gastropexy (fundupexy) in 1976 after describing the structural changes that occur with GDV (Funkquist, 1976). She recommended surgically fixing the gastric fundus to the left abdominal wall. This differs from the techniques used today that all fix the gastric antrum to the right abdominal wall. These are considered antral gastropexy techniques and include incisional gastropexy, tube gastropexy, circumcostal gastropexy, and belt loop gastropexy (Ellison, 1993). All these different techniques have been shown to decrease the rate of GDV reoccurrence by forming permanent adhesions but each has distinct advantages and disadvantages. Advantages of a gastropexy technique include; the formation of strong adhesions, a simple procedure, a short surgical duration, a low complication rate and the ability to decompress the stomach during surgery. Conversely, a weak adhesion between the gastric antrum and the abdominal wall, a long surgical time, a difficult procedure, and a high complication rate are all disadvantages in a gastropexy technique. Unfortunately, there has been no controlled study comparing the advantages and disadvantages of each procedure. Currently, the most common gastropexy procedures are the incisional, belt-loop, and circumcostal gastropexies (Belandria et al, 2009).
**Incisional Gastropexy**

Incisional gastropexy was first described by MacCoy and colleagues (1982). This technique includes the suturing of two incisions, one in the pyloric antrum and one in the body wall (Figure 5). The incision in the pyloric antrum is made half way between the greater and lesser curvature of the stomach and the incision in the body wall is between the twelfth and thirteenth ribs through the peritoneum and internal fascia. The cranial and caudal edges of both incisions are then sutured together. The skeletal structure of the canine chest can be seen in Figure 6 and the anatomical planes of the canine in Figure 7.

The incisional gastropexy is fast and creates a strong adhesion. This surgery also does not enter the stomach lumen which enables a faster, less painful recovery since there is less tissue trauma and suturing required. This technique, however, does not provide a means for decompressing the stomach in order to remove the air as tube gastropexy does. Nonetheless, an incisional gastropexy creates a slightly stronger adhesion than the tube gastropexy. Incisional gastropexy is not as strong in terms of tensile strength as the circumcostal and belt loop gastropexy techniques (Ellison, 1993). The tensile strength indicates the strength of the adhesion between the antrum and body wall created by a gastropexy technique. Tensile strength is found by applying tension to adhesions to find the breaking point. It is important for a gastropexy to create a strong adhesion in order to prevent GDV, however, the tensile force the stomach applies to the gastropexy adhesion in vivo is currently unknown. Therefore, the minimum tensile strength requires to prevent gastric dilatation-volvulus has not been established (Hardie et al, 1996).
Figure 5. Illustration of an incisional gastropexy procedure. Panel A shows the incision made in the pyloric antrum of the stomach between the greater and lesser curvature of the stomach. Panel B shows the incision made in the body wall between the twelfth and thirteenth ribs. C and D show the suturing of the two incisions, first the cranial edges of both incisions are sutured together and then the caudal edges of each incision are sutured (Ellison, 1993).
Figure 6. Skeletal structure of the canine chest (Aspinall and Cappello, 2009).
Figure 7. Anatomical planes and directional terms (Aspinall and Cappello, 2009).
**Tube Gastropexy**

Tube gastropexy (Figure 8), a surgical technique where a catheter is inserted through the abdominal wall and gastric lumen, was first described by Parks and Greene (1976). A French Foley catheter, a catheter with a balloon at the tip insuring the tube maintain in place, is placed through an abdominal wall stab wound on the right side of the canine body. This stab wound is placed ventrally about 4 cm caudal to the last rib. The catheter passes through the layers of the greater omentum. A purse-string suture is made in the pyloric atrum and then a second stab incision is made in stomach lumen. The catheter is inserted into the stomach and inflated. The purse-string sutures are then used to make a seal keeping the tube in place. The tube stays in place for 7 to 10 days before being removed and post-operation care includes the treatment of the open wound in the abdominal wall. The wound typically starts to heal a few days after the removal of the tube (Ellison, 1993).

The biggest advantage to the tube gastropexy is the ability to provide gastric decompression that may be beneficial in the treatment of GDV. The tube can also be used for feeding and medicating the dog post-surgery. This technique creates a permanent adhesion although not as strong as other techniques. The mortality rate when treating GDV surgically is about 15% (Beck et al, 2006). Tube gastropexy has been shown to decrease reoccurrence of GDV but is also associated with a 31% post-surgery mortality rate (Ellison, 1993). Complications associated with this gastropexy technique include premature removal of the tube, leakage, and peritonitis, the inflammation of the peritoneum (Ellison, 1993). The additional post-operative care and complications may explain the mortality rate associated with this gastropexy. Tube gastropexy is beneficial
Figure 8. Illustration of the tube gastropexy procedure. A and B show the insertion of a catheter through a stab incision in the abdominal wall and then through the greater omentum. C shows the catheter being inserted into the gastric lumen and in D the tube is inflated (Ellison, 1993).
when treating a dog already presenting with GDV. The tube allows for decompression of
the stomach as well as tube medication and feeding. However, the additional risks and
costs of the open wound created by the procedure should be considered before using tube
gastropexy as a purely preventative measure.
Circumcostal Gastropexy

The circumcostal technique (Figure 9) was first described by Fallah and colleagues (1982) and includes making one or two submuscular flaps in the pyloric antrum. These flaps are each about 1 by 4cm. An incision also made in the abdominal wall and a tunnel is made through the abdominal muscles around the 11\textsuperscript{th} or 12\textsuperscript{th} rib at the costochondral junction. The caudal submuscular flap is passed through this tunnel, around the rib, and sutured to the cranial submuscular flap. If there is just one flap it is passed through the tunnel around the rib and sutured to the original incisional margin (Fossum et al., 2002).

This technique creates an adhesion twice as strong in terms of tensile strength as the incisional or tube gastropexy procedures and does not cut into the gastric lumen. The stomach is also sutured in a more suitable position anatomically. However, several veterinarians find this technique more difficult and therefore the surgical duration is longer than that of simpler gastropexy techniques. Circumcostal gastropexy has also been associated with rib fracture or pneumothorax. Moreover, circumcostal gastropexy does not provide gastric decompression as tube gastropexy does (Ellison, 1993).
Figure 9. Illustration of a circumcostal gastropexy. A seromuscular flap, either one or two hinged, is made in the pyloric antrum as seen in panel A. Panel B shows the incision made in the body wall between the eleventh and twelfth rib. C shows the use of a hemostat to make a tunnel under the rib and D shows the flap being passed under the rib and sutured to the original gastric margin or other flap (Fossum et al, 2002).
Belt-Loop Gastropexy

Belt-Loop gastropexy (Figure 10) is very similar to circumcostal gastropexy and was first described by Whitney and colleagues (1989). It differs by the fact that there are two incisions made in the abdominal wall and the narrower flap does not pass around a rib. First an incision is made in the gastric antrum near the greater curvature to make a submuscular flap. This U-shaped flap is about 2.5 cm by 4 cm. Two 3-5 cm incisions 2.5 to 4 cm apart are made in the abdominal wall adjacent to the flap. Using forceps, a tunnel is created under the abdominal muscles between the incisions. The flap is passed in the caudal to cranial direction through this tunnel and the flap is sutured to the margins of the original incision.

The belt loop gastropexy is easier to perform than the circumcostal procedure and is not associated with pneumothorax or rib fracture. However, since the base of the flap is not as wide, the adhesion is weaker than the circumcostal gastropexy but still stronger than the incisional and tube techniques. Since it does not pass through the gastric lumen it does not allow for gastric decompression.
Figure 10. Illustration of a belt-loop gastropexy. A shows a seromuscular flap in the gastric anturum and a tunnel being made under two transverse incisions in the abdominal wall. B shows the passage of the flap through the tunnel in the abdominal wall from cranial to caudal. This flap is then sutured to the original gastric margin as seen in C. (Fossum et al, 2002).
LAPAROSCOPY

Laparoscopy was originally suggested as a diagnostic tool in the early 20th century with the first experimental use of laparoscopy performed on a dog in 1901 (Salmeri, 2006). The first laparoscopic surgery in humans was a cholecystectomy in 1987 (Perissat and Vitale, 1991). However, it took until 1990 for laparoscopy to become the golden standard it currently is in human medicine (Salmeri, 2006). It is rare for open laparotomy to be used in humans today; however, it is still commonly used in veterinary medicine. Veterinarians believe that both laparoscopic-assisted surgeries and total laparoscopic surgeries will become a standard in animal care in the near future. Rawlings (2003) suggests that many pet owners demand the same advanced surgical technology they receive to be available for their animals. Research has shown a decreased stress response when a minimally invasive surgical procedure is used over an open surgery technique (Rawlings, 2003). The biggest road block to laparoscopy as a widely available procedure in veterinary medicine is believed to be the associated cost of the equipment and training time. However, the equipment can be used diagnostically and for many surgeries, which helps defer the initial cost. Additionally, training for both veterinarians and assistants in laparoscopic technique and use is widely available; there are many courses and wet labs offered.

While this paper focuses on the use of laparoscopy in surgery, specifically in gastropexy, laparoscopy is also an effective diagnostic tool. Laparoscopy provides a minimally invasive yet accurate diagnosis of lesions, obstructions, and disease. Biopsies taken laparoscopically are superior to ultrasound and biopsy needle techniques since they allow for a better view of the affected area. These views can be magnified and recorded,
hence, it is less likely that a small lesion is missed. Laparoscopically-assisted diagnosis also has a complication rate of less than 2% (Salmeri, 2006) as compared to the 17% complication rate reported for the open tube gastropexy technique (Johnson et al, 1984). However, with laparoscopy there is a limited field of vision and the abdomen cannot be as completely explored as with open exploration. In addition, if a patient is too small, obese, or has abdominal effusions, laparoscopically-assisted diagnosis is not as successful. Lastly, intestinal biopsies still have to be exteriorized and biopsied using standard procedures (Salmeri, 2006). While laparoscopic-assisted diagnostics is not always practical, Rawlings (2003) suggests many other non-surgical uses for laparoscopy including vaginoscopy in order to inseminate frozen semen into a dog. He also suggests that taking laparoscopic images of normal and diseased ears, lungs, kidneys, etc. can be used to educate pet owners potentially increasing the likelihood the owner will consent to treatment (2003). Using the laparoscopy equipment for purposes other than surgery is not only practical but cost effective.

Many pet owners are aware of the dangers of bloat or GDV in large and giant breeds, but based on the number of GDV cases seen each year, not enough prophylactic gastopexies are performed. It is often breeders that invest in prophylactic gastropexy surgery if they raise a breed with a high-risk for GDV. Often times, the gastropexy is performed when a breeder brings in a dog to be neutered. The minimally invasive nature of laparoscopically-assisted and total laparoscopic gastropexy may increase the number of dog owners who choose to invest in a prophylactic gastropexy for their canine (Rawlings, 2002). With a wider availability of laparoscopic gastropexy techniques, Rawlings(2002) believes that there will be more gastropexies performed every year.
Currently, there are many surgical procedures in the veterinary field that can be
done laparoscopically or assisted with a laparoscope. These include ovariohysterectomy
(spay), castration (neuter), gastropexy , colopexy (this is similar to gastropexy and
includes the fixation of the colon to the abdominal wall to prevent rectal prolapse),
cystotomy to remove bladder stones, cystopexy (attachment of the gallbladder or urinary
bladder to the abdominal wall) to prevent the bladder from bending and foreign body
removal via gastrostomy or opening of the stomach (Rawlings, 2003). This is not the full
list of reported laparoscopic surgeries; almost any veterinary surgery can be done either
total laparoscopically or with laparoscopic assistance. This minimally invasive tool is
very adaptable and has a lot of room for growth in the field. Many of the advantages and
disadvantages described for both laparoscopic gastropexy techniques and laparoscopic-
assisted gastropexies are the same for all surgeries that utilize the laparoscope.
LAPAROSCOPIC GASTROPEXY

Laparoscopic-assisted Gastropexy (LAG)

Laparoscopy requires the abdomen to be distended with carbon dioxide gas to aid viewing the abdomen. Use of trocars, (hollow cylinders with a sharply pointed end) prevent the carbon dioxide from escaping and also provide portals for the laparoscope and other surgical instruments into the abdominal cavity (Rawlings, 2003). A laparoscopic-assisted gastropexy technique was first described by Thompson and colleagues (1992) during an ACVS Veterinary Symposium in 1992. The procedure uses the laparoscope in order to view, grasp and partially exteriorize the pyloric antrum. The gastropexy can then performed the same as in open procedures. Thompson and colleagues (1992) described a laparoscopic incisional gastropexy. Once the antrum is sutured to the abdominal wall, the antrum is then placed back into the body, the incision closed in three layers, and the trocar ports removed.

Two trocar sites, typically 10-12 mm, are required for laparoscopic-assisted gastropexy. One is placed on the ventral midline 2 to 3 cm caudal to the umbilicus and the other lateral to the right margin of the rectus abdominus and 3 cm caudal to the last rib (Rawlings, 2002b). The laparoscope is inserted into the first trocar site while laparoscopic Babcock forceps, forceps with loop blades, are inserted into the second site in order to grasp the antrum. This trocar site is extended making a 4 cm incision parallel to the last rib and the forceps and antrum are exteriorized through this incision. The laparoscope is used in order to ensure that the antrum is not twisted during this process. In the laparoscopic-assisted gastropexy described by Rawlings (2002b), an incision is made in
the seromuscular layer of the atrum and then the seromuscular layer is sutured to the transverses abdominus muscle (Figure 11). The incisions are sutured and then the first trocar site where the laparoscope is placed is removed and that incision is also closed (Rawlings, 2002b).

While a full thickness incision through the body wall is still required, it is much smaller than the incision required for open gastropexy. This surgery is simple and can be performed faster than the conventional open surgery once the laparoscopic skills are mastered. A shorter surgery equates to less time under anesthesia and less discomfort in comparison to open laparotomy (Robbins, 2009). In a study by Rawlings and colleagues (2002), only one of the twenty-three dogs that received a laparoscopic-assisted gastropexy developed a complication, a small fistula at the gastropexy site, and GDV did not reoccur in any of the dogs.

This laparoscopic-assisted gastropexy technique can be used as a preventative measure before the dog ever develops GDV as well as when a dog actually presents with GDV. Decompression and repositioning of the stomach, as well as the gastropexy, can be done laparoscopically. However, the stomach cannot be palpated when GDV is treated laparoscopically which is helpful in determining if there is tissue damage. If extensive damage to the gastric wall or splenic thrombosis or clotting is observed, it is recommended that the surgeon switch over to an open procedure (Rawlings and Mahaffey, 2002). When dealing with a prophylactic surgery the only reason that an open surgery may be preferred over a laparoscopically-assisted surgery would be patient size or obesity.
Figure 11. Illustration of a laparoscopic-assisted gastropexy. A portion of the antrum is exteriorized and the gastropexy completed by making an incision in the seromucular layer of the stomach and this layer is then sutured to the transverses abdominus muscle of the abdominal wall. GM- gastric mucosa, TA= transverses abdominus muscle and SM= seromuscular layer of the stomach (Rawlings, 2002b).
Total Laparoscopic Gastropexy (TLG)

Laparoscopic-assisted gastropexy but not total laparoscopic gastropexy techniques are currently being used in select veterinary practices. A recent study conducted by Mayhew and Brown (2009) compared a laparoscopic-assisted gastropexy and two total laparoscopic gastropexy techniques using intracorporeal suturing, or suturing through a body cavity with the use of ports. Intracorporeal suturing has been used in some veterinary surgeries and is common in human surgery. This study compared a hand-suturing technique and use of a suture-assist device, the Endostich. Intracorporeal suturing requires hand-to-video coordination rather than hand-to-eye coordination. Therefore, intracorporeal suturing can be difficult, however, it allows for total laparoscopic surgery which is less invasive than a laparoscopic assisted surgery.

The TLG technique

In the TLG technique described by Mayhew and Brown (2009), no full thickness body incisions are necessary. The technique uses three trocar sites, the first located on the ventral midline just below the navel. The laparoscope is inserted in this first site and the abdomen is distended with carbon dioxide. This is the same as in the LAG technique. The two remaining trocar sites are also located on the ventral midline. The second is 3-4 cm caudal to the xiphoid process and the third in-between the first two portals. Trocar placement can be seen in Figure 12. The laparoscope is moved to the middle trocar portal and a clear view of the antrum is obtained using a blunt probe.
Figure 12. Portal placement in a total laparoscopic gastropexy (Wilson et al, 1996).
A curved needle and suture is inserted through the body wall caudal to the last rib and lateral to the midline. This needle is grasped by laparoscopic parrot-jaw needle holders inserted in one of the instrument portals, and then used to make a full thickness bite through the antrum. The needle and suture are passed back outside the body through the site they were inserted and clamped in order to create a temporary anchor of the antrum to the body wall. Laparoscopic scissors are then used to make an incision in the transverse abdominis muscle and through the seromuscular layer of the stomach as was done in the LAG technique. Both incisions are only partial thickness incisions. The lateral and medial components of each incision (the seromuscular layer incision and the transverses abdominis muscle incision) are sutured. This follows the incisional gastropexy technique previously discussed. The suturing differs based on the intracoporeal suturing technique. After the incisional gastropexy is completed the instruments and laparoscope are removed from the trocar sites, carbon dioxide is removed from the abdomen and the portal sites are sutured.

**Hand-suturing technique**

A needle and suture are passed through the body wall near the gastropexy site and the needle holders are used to suture the incisions as mentioned above. Laparoscopic hook scissors pass through one of the trocar sites and are used to cut suture ends.
**Endostitch Technique**

The Endostitch needle is a single use instrument that has a double tipped straight needle and attached suture. The handle allows for the suture to be passed between tissue by switching the needle from one tip to the next when closing the handles and flipping a toggle lever. Placing pressure on the suture-free end of the suture and then using the handles and toggle to switch the needle to the other jaw tip creates a knot. This instrument is pictured in Figure 13.

After practice using the Endostitch device, Mayhew and Brown (2009) suggested that the attached suture be cut down to 30 cm in length. A suture length greater than 30 cm prematurely knotted and a suture less than 30 cm was insufficient to complete the gastropexy. The Endostich was inserted into the most cranial trocar portal and the incisions were sutured as previously described. Two Endostich devices were used, one to suture the lateral components of the incisions and one for the medial components of the incisions.

**Stapled Technique**

Total laparoscopic gastropexy can also be done utilizing a intracoporeal suturing or laparoscopic stapler. TLG using a stapler device was compared to an open incisional gastropexy technique in a study done by Hardie and his colleagues (1996). Cannucale placement was similar to that as described by Mayhew and Brown (2009). A submucosal
Figure 13. The Endostich suturing device. (Huhn, 2004).
tunnel was made in the gastric antrum using Metzenaum scissors and Kelly forceps. Another tunnel was made in the right abdominal wall caudal to the last rib. These tunnels were stapled together using a 35 mm laparoscopic stapler and then the tunnel opening was closed using a laparoscopic hernia stapler. This is shown in Figure 14.
Figure 14. A laparoscopic stapled gastropexy. A laparoscopic stapler is used to staple the tunnels in the antrum and the abdominal wall together as seen in A. The opening of the tunnels are stapled using a laparoscopic hernia stapler (Hardie et al, 1996).
Comparison of Laparoscopic and Open Gastropexy Techniques

Advantages of Laparoscopic Gastropexy Techniques

In addition to the potential increase in prophylactic gastropexies performed with greater availability of laparoscopic gastropexies, this technique reduces post-operative stress, speeds up post-surgical recovery and requires lower doses of analgesia since there is less pain involved (Rawlings, 2003). The quick recovery results in a reduced hospitalization time (Hardie et al, 1996), which therefore decreases the costs associated with hospitalization. Laparoscopic-assisted gastropexies also create strong adhesions between the antrum of the stomach and the body wall on par with open gastropexy techniques. The average tensile or breaking strength for a laparoscopic-assisted gastropexy was 76.55 ± 22.78 N where an open belt-loop gastropexy had a tensile load of 109.21 ± 22.29 N (Wilson et al, 1996). This is similar to the tensile strength found for other gastropexy surgeries. There was also evidence of formation of dense fibrous tissue (Figure 15), an indication of a strong adhesion. It is also believed that a laparoscopic technique has a lower association with morbidity than the comparable open technique (Mayhew and Brown, 2009). While morbidity has not yet been compared between laparoscopic and open techniques in veterinary medicine, Inoue and colleagues (2003) found that in human medicine, a laparoscopic technique was associated with a shorter recovery time and patients became physical activity sooner after surgery than with an open technique.
Figure 15. Histological appearance of an adhesion created by a laparoscopic gastropexy 50 days after surgery (Wilson et al, 1996).
Disadvantages of Laparoscopic Gastropexy techniques

Although laparoscopic techniques are less invasive than an open surgery, these techniques require additional training and costs. While the equipment can be used diagnostically and for other surgeries to defer the cost to the veterinarian, the cost of a laparoscopic surgery is greater than that of an open surgery for the dog owner. Additionally, the use of cannulae can lead to subcutaneous emphysema or the presence of air under the skin. This is due to carbon dioxide leaking around the port when the seal was not tight. Making several attempts to place the cannula enlarged the hole in the abdominal wall allowing gas to escape (Hardie et al., 1996). Subcutaneous emphysema is not a serious condition but can be uncomfortable and obstruct breathing. It is suggested that with experience in trocar placement, this issue will resolve itself.
Comparison of LAG and TLG Techniques

With the demand for minimally invasive surgeries in veterinary medicine, comparison of TLG and LAG techniques is a highly relevant topic. Since the TLG technique does not require a full thickness incision or as deep of an incision as the LAG technique does, it was proposed that a total laparoscopic gastropexy would further decrease the pain, potential of morbidity, and post-operative care, while increasing the recovery rate. The belief is that while laparoscopic-assisted surgery is less invasive than an open surgery, total laparoscopic surgery is less invasive than the laparoscopic-assisted surgery.

Based on the results from the study done by Mayhew and Brown (2009), the dogs that received a total laparoscopic gastropexy had a less dramatic decrease in activity post-surgery than the dogs that received a laparoscopic-assisted surgery. When adjusted for body weight, it was estimated that there would be a 44% decrease in activity after surgery for the dogs receiving a LAG and only an 11-19% decrease in activity for dogs receiving a TLG (Figure 16). Activity was monitored before and after surgery using a device that measured the intensity, duration, and frequency of movement. This result is presumably due to the lack of a full-thickness incision in the TLG technique. It was shown to take about 4 to 5 days longer for dogs that received a LAG to be as active as those that received a TLG. However, the study is limited by the number of dogs and inability to strictly monitor post-surgical activity since they were all client-owned dogs (Mayhew and Brown, 2009). Another advantage the TLG technique provides over the LAG technique
Figure 16. Activity in canines before and after LAG or TLG surgery (Mayhew and Brown, 2009).
is the associated risk of seroma and fistula formation with a full-thickness incision (Mayhew and Brown, 2009). While more research needs to be done on total laparoscopic gastropexy techniques, there are definite benefits to total laparoscopic gastropexy. Nonetheless, each surgical technique comes with advantages as well as disadvantages. The disadvantages of the TLG technique include the longer surgical time, greater expense, and increased risk of perforating the stomach when compared to other techniques.

TLG also has been known to perforate the stomach 14% of the time (Mayhew and Brown, 2009) yet this may be due to unfamiliarity with intracorporeal suturing or stapling techniques. It is likely that with time and practice stomach perforation will occur less frequently. The biggest disadvantage of the TLG technique is the additional time it takes to complete the surgery which also means additional time under anesthesia. LAG was faster than both TLG techniques and while the second five procedures had shorter gastropexy times as the surgeon became more comfortable with TLG techniques, the second five procedures for the LAG technique also had shorter gastropexy times when compared to the first five procedures (Table III). While it is believed that the laparoscopic-assisted technique will continue to be faster, it is estimated the difference in time between the LAG and the TLG techniques will significantly decrease as intracorporal suturing skills are honed. The difference between the hand-sutured TLG and the LAG technique was only 18.9 minutes which is not clinically significant (Mayhew and Brown, 2009). As before, more research should be done comparing surgical duration of LAG and TLG techniques since the surgeon had never performed a TLG before.
Table III. Gastropexy times for laparoscopic-assisted gastropexy and two total laparoscopic gastropexy techniques, one using hand suturing and the other using the Endostich suturing device (Mayhew and Brown, 2009).

<table>
<thead>
<tr>
<th>Gastropexy Time (95% Confidence Interval)</th>
<th>Lap Assisted</th>
<th>Hand Suture</th>
<th>Endostich</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 5 procedures</td>
<td>34.3 minutes (25.3, 43.2)</td>
<td>53.2 minutes (44.2, 62.1)</td>
<td>61.8 minutes (52.8, 70.7)</td>
</tr>
<tr>
<td>Second 5 procedures</td>
<td>25.3 minutes (16.4, 34.3)</td>
<td>44.2 minutes (35.3, 53.2)</td>
<td>52.8 minutes (43.9, 61.8)</td>
</tr>
</tbody>
</table>
Lastly, the expense of a total laparoscopic gastropexy technique must be taken into consideration. The laparoscopic equipment, as already mentioned, is expensive and requires specialized training. The additional laparoscopic instruments utilized in TLG is also an added cost when comparing LAG and TLG techniques. Each LAG technique requires laparoscopic instruments such as laparoscopic needle holders, hook scissors, and any disposable staple or suture devices that are not needed in LAG procedures. However, if other laparoscopic surgeries are done in the clinic, these instruments can be used for those procedures as well deferring the cost. Additionally, the use of disposable suturing devices is comparable to the use of expensive disposable stapling equipment that is used in open surgery (Mayhew and Brown, 2009). Expense and training time is a factor to take into consideration but the benefits of a less invasive and painful surgery should not be forgotten.

With minimally invasive surgery becoming more popular, further research should be done on laparoscopic techniques for gastropexy in general but especially focusing on total laparoscopic gastropexies. The study by Mayhew and Brown (2009) has suggested that total laparoscopic gastropexy should not be ruled out for use in veterinary medicine. One of the largest disadvantages of total laparoscopic gastropexy is the longer surgery time. In human medicine it has been shown that experience with total laparoscopic techniques significantly decreased surgical time (Breaux et al, 2007), however this has not been tested in veterinary medicine. A study done using surgeons experienced and comfortable with both laparoscopic-assisted and total laparoscopic gastropexy techniques can determine whether or not the time difference between surgical techniques is significant or not. Furthermore, a study monitoring activity of dogs undergoing total
laparoscopic gastropexy and open gastropexies could potentially strengthen the argument that canines are in less pain and recover faster with minimally invasive surgeries. Lastly, and most importantly, long term gastopexy strength should be assessed for gastropexies performed completely laparoscopically with the use of intracorporeal suturing. It has already been reported that laparoscopic-assisted gastropexies create a long term permanent adhesion that will successfully prevent the occurrence of GDV. The study by Hardie and colleagues (1996) found that the laparoscopic stapled gastropexy creates an adhesion similar in strength to that of accepted open surgery techniques and therefore decreases the chance of GDV reoccurrence. However, the TLG techniques described by Mayhew and Brown (2009) have not been tested for tensile strength and therefore it is uncertain whether this technique will prevent volvulus, an important factor in deciding whether or not to employ this technique in a clinical setting.
LITERATURE CITED


Huhn, J. C. 2004. Intracorporeal suturing in minimally invasive surgery. DVM.


