Understanding Gastric Dilatation-Volvulus or "Bloat"

Introduction

Gastric dilatation-volvulus (GDV) is more commonly referred to as "bloat". It occurs when a dog's stomach becomes dilated and distended due to an accumulation of gas or fluid (dilation) and then rotates around its small axis (volvulus), trapping the gas or fluid inside. Dilatation without volvulus (Simple bloat) can also occur separately. While still causing clinical signs of bloat, dilatation without volvulus is more straightforward to treat.

GDV is a condition that is most common in large- and giant-breed dogs, as well as in dogs that have deep chests. Although it can occur in mixed breed dogs, it is most common in purebred dogs, particularly German Shepherd Dogs and Great Danes. However, various studies have suggested that a number of other breeds may also be at increased risk for GDV.

Signs of GDV should be considered an emergency, as the condition can progress quite rapidly and cause significant damage to multiple organ systems. Although, thanks to improvements in treatment, fatalities associated with GDV have decreased enormously in the past few decades, left untreated it is almost universally fatal.

Warning Signs of GDV

Owners of large- and giant-breed dogs should be educated about the early signs of bloat, as prompt treatment is associated with survival rates of greater than 80 percent.

The Signs of GDV Include:

- **Distended (swollen) abdomen**
- **Abdominal pain**
- **Excessive drooling**
- **Unsuccessful attempts to vomit or belch**
- **Dry heaving**
- **Weakness**
- **Shortness of breath**
- **Pale gums**
- **Hypothermia**
- **Lethargy, possibly to the point of collapse**
- **Reluctance to "settle"**

Dogs experiencing bloat may become anxious due to the pain it causes. Therefore, a change of temperament in combination with any of the above clinical signs should also be considered a warning sign of bloat.

Background

Gastric dilatation-volvulus (GDV), commonly known as bloat, is a rapidly progressing and devastating condition that can develop in multiple breeds of dogs. Bloat is of foremost concern to the AKC Canine Health Foundation and its donors, and as such required a major research effort to identify the underlying mechanisms of this disease. In response to donor concern, CHF launched a Bloat Research Initiative in 2013 to better define, and ultimately eradicate, bloat in dogs. Two grants were funded as the result of this effort, and subsequently the journal Topics in Companion Animal Medicine (Elsevier, Inc.) dedicated its entire September 2014 issue to reviewing the state of the science in bloat. Two of CHF's funded researchers, Dr. Claire Sharp and Dr. Liz Rozanski, were the editors of this special bloat edition. Following is a summary of the articles published in this journal, so that dog owners can better understand the state of science in bloat, how it is treated, and how research is our greatest hope to move us towards prevention.

Risk Factors for GDV

Over and above the baseline risk in a particular breed, a number of preventable and non-preventable factors are associated with the likelihood of developing GDV. Unsurprisingly, GDV is more common in dogs where a first degree relative has experienced an episode of GDV, likely reflecting the heritability of one or more risk factors.

Other risk factors often reflect anatomical changes that could predispose a dog to either dilation or volvulus. For example, GDV is more common in older dogs than younger dogs, possibly because of age-related stretching of the hepatogastric ligament that normally helps to keep the stomach in place. It is also associated with both increased body weight and leaner body condition. Although that may seem paradoxical, it is actually a reflection of two separate types of risk. Larger dogs are, in general, more likely to experience bloat because there is more room in their abdominal cavity for the stomach to expand and move around. In contrast, being underweight for size is a risk because there is less abdominal fat to serve as padding and keep the stomach in place. Finally,

fearful and nervous temperament has been associated with an increased risk of GDV, as has a recent experience of environmental stress, such as staying in a kennel or going on a car journey.

Various dietary factors have also been associated with the risk of GDV, although these associations are less clear. Feeding choices that may increase the risk of GDV include providing a dry food that contains oil or fat among the first four ingredients; feeding a large volume of food at one time instead of splitting food into two or more meals; and feeding a single food type without mixing in supplementary table food, fish, or eggs. In addition, contrary to popular wisdom about raised feeders, more recent research suggests that using an elevated food bowl may actually increase the risk of GDV. As for mild exercise after eating, there is no consensus about whether it increases or decreases the risk of GDV as different studies have shown opposing results.

The Pathogenesis of GDV

As of yet, there is no clear understanding of why some dogs develop GDV when others, with seemingly identical risk factors, do not. However, research suggests that one possible contributor to the development of GDV may be differences in gut motility between dogs. A decrease in gut motility has long been associated with GDV, although until recently it has not been clear whether the observed decrease was a cause of GDV, a consequence of GDV, or both. Several studies attempting to clarify the nature of the association have found that the decreased gut motility seen in dogs with GDV is unlikely to be a consequence of either treatment or damage caused by dilation and volvulus. That suggests that it may actually be a precipitating factor for GDV. However, it is not known whether apparently healthy dogs that never develop disease actually have altered GI motility as well. If such an association could be confirmed, noninvasive gut motility monitoring might eventually be one way to identify dogs that are at particularly high risk for GDV.

Despite the aforementioned research into the role of gut motility, the specific mechanisms that lead to GDV development remain poorly understood. In a dog with GDV, distension and rotation of the stomach leads to the compression of the surrounding blood vessels. This causes a decrease in perfusion of the heart and surrounding organs, with the potential for long-term tissue damage, necrosis, and even death.

On its own, relieving the pressure on surrounding vessels and organs is not enough to avoid GDV associated organ dysfunction. Ischemic damage, which is defined as a loss of blood flow to various organs, can be compounded by problems during post-operative reperfusion, once the distension of the stomach has been alleviated and blood flow is restored. In fact, ischemic reperfusion injury (IRI) and consequent systemic inflammatory response syndrome (SIRS) and multiple organ dysfunction (MOD) are the most serious postoperative complications associated with GDV. IRI is a two-step process whereby cell death during the ischemic phase produces precursors that trigger formation of reactive oxygen species (ROS) once oxygen is present during reperfusion. ROS inflict damage to proteins, DNA, and RNA and cause lipid peroxidation of cell membranes that perpetuate cell death and trigger systemic inflammation. As reperfusion is critical for restoration of blood flow, techniques to minimize IRI, SIRS and MOD such as lidocaine administration prior to and during surgery are discussed below.

The multiple organ dysfunction that occurs as a consequence of GDV and subsequent IRI can cause cardiac arrhythmias, disseminated intravascular coagulation, low blood pressure, gastric ulceration, and other systemic concerns that can range in severity from moderate to life-threatening. Other relatively common sequelae of GDV include aspiration pneumonia and acute kidney injury (AKI). Fortunately, the risk of development of these conditions can be managed, at least somewhat, through postoperative care.

Diagnosis and Management of Acute GDV

Initial suspicion of GDV is prompted by an evaluation of the same warning signs that owners look for, including distension of the abdomen, drooling, failed attempts to vomit or belch, rapid heart rate and pale gums. Diagnosis is confirmed with abdominal radiography. Veterinarians may also perform an electrocardiogram (ECG) to

detect abnormal heart beats that commonly occur alongside GDV and laboratory testing to look for abnormalities in organ function.

The goal of emergency GDV treatment is stabilization and prompt surgical correction. Fluid therapy to correct shock and pain relief are provide, and releasing the pressure in the abdomen by relieving fluid and gas accumulation. Surgery is then performed to rotate the stomach back into its initial position. Finally, a procedure known as gastropexy ("tacking") is used to permanently attach the stomach to the abdominal wall, in order to prevent volvulus from occurring again. Gastropexy has been shown to drastically reduce the likelihood of a recurrence of GDV, and it can also be used as a preventative procedure in dogs considered at high risk.

Although treatment has drastically improved survival from GDV, there are certain factors that remain associated with poorer outcomes and decreased survival. These include a high lactate concentration that remains high after surgery, hypotension at any time during treatment, peritonitis, and the need for a splenectomy and/or partial gastrectomy during surgery. Speedy treatment is also an important factor in obtaining positive outcomes, since a time lag of over five hours from onset of clinical signs to hospital admission is associated with increased morbidity and mortality.

Postoperative Management

After initial surgical resolution of stomach rotation and distension, appropriate postoperative management is critical for maximizing survival. Postoperative management consists of pain management, maintenance of appropriate perfusion with IV fluids and/or transfusions, and monitoring for evidence of multiple organ dysfunction or sepsis. While a part of surgical correction of GDV involves an abdominal exploratory, it will still be important to watch dogs closely for evidence of previously un-recognized gastric necrosis. In dogs with slower recoveries, serial abdominal focused assessment with sonography for trauma (aFAST) is also recommended postoperatively. While a mild to moderate volume of fluid isn't a cause for concern, the presence of bacteria, large numbers of degenerate neutrophils, or low abdominal fluid glucose concentration, could be a sign of gastric necrosis.

Pain management after surgery is important, but care should be taken to avoid the use of NSAIDS to reduce the likelihood of gastrointestinal or renal side effects. Opioids are acceptable for pain treatment after surgery, and lidocaine and/or ketamine infusions can be used to reduce opioid dosing. Lidocaine is particularly worth consideration as a treatment option, as it also has the potential reduce reperfusion damage to both the heart and gastrointestinal system. In one study lidocaine (2mg/kg given as an IV bolus) administered before any other medical intervention, followed by constant rate infusion of 0.05mg/kg/min for 24 hours during initial patient management significantly decreased AKI, cardiac arrhythmias, multiple coagulation disorders, and hospitalization period compared with historical control dogs. Mortality rate in the treatment group was lower (10%) compared with the control group (24%), albeit insignificantly so. As such, some clinicians feel lidocaine in combination with conservative fluid management may be at the cornerstone of successful therapy for uncomplicated GDV. However, lidocaine, fluid, and pain management may be insufficient in more complicated cases where the reduction or remediation of GDV-induced dysfunction in various organ systems is an important component of postoperative care.

Addressing Cardiovascular and Respiratory Dysfunction

Cardiovascular and respiratory changes during GDV contribute to many of the observable signs of the condition, including changes in heart rate, pale gums, weak pulses, and abnormal heart beats. Damage to the cardiovascular system causes significant morbidity, and it is thought to be one of the major causes of early mortality in dogs affected by GDV. Common types of post-GDV cardiovascular dysfunction include a variety of arrhythmias, shock from low blood pressure, and myocardial dysfunction, leading to decreased oxygenation of organ tissue and an increased risk of multiple organ dysfunction or failure.

Approximately 40 percent of dogs with GDV experience cardiac arrhythmias, primarily ventricular arrhythmias. This may be due to the presence of myocardial ischemia or an increase in circulating concentrations of various cardio-stimulatory and cardio-inhibitory substances such as catecholamines and pro-inflammatory cytokines. Elevated cardiac troponin concentrations are associated with increased severity of ECG abnormalities and poor patient outcomes after surgery. In addition to its effects on the cardiovascular system, gastric dilation can also affect respiratory function in several ways. Distension and volvulus can reduce blood flow to the lungs and decrease lung volume from compression. Additionally, unproductive retching and anesthesia/passage of a gastric tube may lead to aspiration pneumonia.

Addressing cardiovascular dysfunction in the postoperative period is done in part through appropriate use of IV fluid therapy. Conservative but adequate therapy is advised, as persistent hypovolemic shock is relatively rare after GDV. In fact, hypovolemic shock should prompt a search for a missed source of hemorrhage or new-onset of sepsis. Fluid therapy typically includes a rapid bolus of crystalloid (e.g. 0.9% saline or lactated Ringer solution) to restore volume, then IV support as needed. Some dogs require blood transfusions for support of coagulopathy or to treat blood loss.

Perfusion parameters, such as heart rate, capillary refill, lactate, blood pressure, packed cell volume, serum creatinine, and urine output can be used to determine whether more aggressive fluid therapy is appropriate. Regular monitoring of electrolytes and acid-base status is also important, and supplementation of IV fluid with potassium can be used as needed. If colloid use is indicated,

some clinicians believe natural colloids (e.g. Plasma) should be used instead of synthetic ones whenever feasible to reduce the risk of possible kidney damage and canine albumin use is preferable to human to reduce the risk of an immune-mediated reaction.

ECG monitoring of dogs for 24-48 hours after surgery is another important component of postoperative management, as arrhythmias are quite common. Although some arrhythmias are not preventable, others can be the result of treatable concerns such as electrolyte imbalances or hypoxemia. While most ECG abnormalities are self-limiting, if sustained ventricular tachycardia is present even after appropriate fluid resuscitation, lidocaine or less commonly procainamide treatment is indicated. Anti-arrhythmic treatment is also indicated in the presence of "R on T phenomena" or multiform ventricular premature complexes, and lidocaine has also been shown to reduce the risk of IRI when given very early on in treatment, during initial stabilization. Labored respiration is uncommon after GDV, and dogs with difficulty breathing should be closely evaluated for an underlying cause, with thoracic radiographs and careful examination. Cardiomyopathy, particularly in Dobermans, may be unmasked by anesthesia and surgery. Aspiration pneumonia should be treated with appropriate antimicrobial IV therapy and monitored closely during the postoperative period. Dogs should also receive oxygen if they are experiencing hypoxemia or difficulty breathing, and in rare cases, mechanical ventilation may be necessary.

Addressing GI Dysfunction

Gastric necrosis is one of the most serious potential outcomes of GDV. Decreased blood flow to areas of the GI tract can lead to injury, necrosis, and eventually, if undetected, septic peritonitis. As part of surgical correction of GDV, exploratory surgery should be performed and the stomach carefully evaluated. If the stomach appears necrotic, the affected portion may be removed. Somewhere between 19 and 41 percent of dogs with GDV require partial gastrectomy to remove dead tissue. In general, a small to moderate resection is well-tolerated, but very large areas of gastric necrosis or if the necrotic segment involved the esophagus, resection may not be possible. Additionally, in some cases, it is possible that the stomach looks "ok" at surgery but later a piece dies, and results in a hole forming in the stomach and the subsequent development of septic peritonitis.

Dogs with GDV also commonly experience damage to the spleen, including vascular avulsion, intravascular thrombosis, splenic torsion, and infarction. Up to 20 percent of dogs may require splenectomy after an acute episode of GDV. In contrast to people, splenectomy is not commonly associated with long-term risks; however, it may increase the recovery time from a GDV.

Because of the frequency of post-operative gastric clinical signs including nausea, anorexia, and vomiting, pharmacotherapy for gastric distress is an important part of the treatment of GDV. This usually takes the form of proton pump inhibitors or H2 receptor agonists used as antacids. However it may also include use of the gastroprotectant sucralfate, or the use of prokinetics/pro-motility agents for dogs with evidence of postoperative ileus or regurgitation. Metoclopramide is usually the first choice prokinetic, but erythromycin and/or ranitidine can also be used. Finally, an antiemetic, such as Maropitant, should be used in any dogs with postoperative vomiting to reduce the risk of further GI irritation or aspiration pneumonia.

Although there are no specific nutrition recommendations for dogs with GDV, it is generally accepted that early, enteral feeding is helpful for recovering gastrointestinal motility. Most dogs with GDV will begin eating on their own within 1-3 days after surgery; however, more complicated cases may require nasogastric or nasoesophageal tube feeding. Parenteral nutrition is also an option, but enteral nutrition is a better choice, except when protracted vomiting is an issue.

Addressing Kidney Dysfunction

Acute kidney injury (AKI), as measured by a serum creatinine concentration of greater than 2mg/dL after 24 hours of intravenous fluid, can also occur during GDV, and it is a significant predictor of death. Kidney damage may be caused by hypoperfusion, shock, inflammatory damage, IRI, clotting concerns, or even complications of medical treatments used for dogs with GDV – including possibly NSAIDs for pain relief or synthetic colloids for fluid resuscitation.

Monitoring dogs for small increases in serum creatinine levels can help veterinarians recognize early signs of AKI, even in cases where absolute levels are still in the normal range. When AKI is suspected, placement of an indwelling urinary catheter can then be used to assess urine output and fluid balance. Dogs that ex-

perience signs of over hydration should be treated with an "ins and outs" fluid regimen, including the use of diuretics. Fenoldopam is a selective dopamine-1 receptor agonist that increases renal blood flow and GFR while inducing vasodilation and selectively increasing both renal-cortical and outer-medullary blood flow. It is a better choice than dopamine for the prevention and treatment of canine AKI. However, the mainstay of preventing AKI is maintaining adequate perfusion to the kidneys with fluid therapy.

Addressing Coagulation Dysfunction

Disseminated intravascular coagulation (DIC) is a form of organ dysfunction that can be seen in dogs with GDV. DIC and other types of coagulation dysfunction can be assessed with thromboelastography and also observed through measurement of coagulation parameters such as platelet counts, prothrombin time and activated partial thromboplastin times. Evidence of coagulation dysfunction is associated with increased mortality and risk of gastric necrosis. Some coagulation dysfunction may be avoidable by prompt correction of GDV and maintaining adequate perfusion.

Addressing Lactate and Other Metabolic Abnormalities

Electrolyte and venous blood-gas analysis can be used to monitor acid-base status and potassium or magnesium disturbances. Such monitoring is important, because elevated lactate concentration and other metabolic changes are indicators of poor prognosis. Understanding and treating the underlying causes of any detected abnormalities plays an important role in long-term health after GDV.

Lactate, in particular, is considered a reliable prognostic indicator for GDV. Dogs that present with moderate to extreme increases in whole blood lactate that remain elevated after fluid resuscitation are less likely to survive than dogs who have a lower initial lactate level or whose levels drop 40 percent or more after fluid resuscitation. Moderate to high whole blood lactate levels (5-10 mmol/L), and hyperlactatemia that persists for more than 12 hours, are also associated with complications such as gastric necrosis, and dogs with sustained or extreme hyperlactatemia are likely to require more lengthy (and expensive) care. With intensive treatment, survival is possible in many of these animals, but it is more difficult to be certain of than it is for dogs who never experience lactate levels of >6mmol/L or whose levels drop at least 40% in the 12 hours following surgery. Persistent elevation in lactate should prompt a search for the underlying cause; these may include on-going hemorrhage or organ necrosis.

The Role of Gastropexy in the Treatment and Prevention of GDV

Gastropexy, the permanent surgical attachment of the stomach to the abdominal wall, plays a critical role in the prevention of both initial and recurrent GDV. Whether done as part of surgical treatment of a GDV episode, or prophylactically in dogs that are considered to be high risk, attachment of the stomach to the abdominal wall is an effective way to prevent torsion and volvulus. Thus, even if dilation occurs, clinical signs are less severe and treatment is more easily managed than in animals where rotation of the stomach has caused a complete blockage of the stomach entrance.

Used after an episode of GDV, gastropexy lowers the risk of recurrence from around 80 percent to less than five percent, and gastropexy should is always performed as a part of surgical treatment of GDV. In dogs considered at very high risk of GDV, such as Great Danes, prophylactic gastropexy may be performed as a stand-alone procedure. One challenge is that it is hard to know which dogs truly benefit from prophylactic gastropexy, as it is impossible to know the risk of an individual dog. Most veterinarians and many breeders of high-risk dogs strongly advise the procedure to prevent dogs from having a GDV as they age. At a minimum, prophylactic gastropexy is indicated for dogs of high-risk breeds that are undergoing ovariohysterectomy, splenectomy, or exploratory celiotomy for any reason.

Gastropexy Techniques

Gastropexy can be performed either as open surgery or as minimally invasive surgery. The goal in all surgeries is the same, to form adhesions that will permanently fix the stomach in place along the body wall. Although the specific technique chosen for gastropexy is more a function of surgeon familiarity than relative efficacy, proper location of the gastropexy is critical to avoid complications. The procedure is always performed on the right side, near the last rib, in order to avoid creating a bend or kink in the stomach that could impede gas or fluid outflow.

Types of open surgery used to adhere the stomach to the abdominal wall include incisional, belt-loop, circumcostal, and incorporating gastropexy as well as gastrocolopexy. Incisional gastropexy is by far the most common version of the open procedure performed today, and it is highly safe and effective. Minimally invasive procedures for gastropexy are associated with less postsurgical discomfort and faster recovery than open surgeries, although they are only appropriate for prophylactic surgery – not in the aftermath of GDV. Options for minimally invasive techniques include the grid approach, endoscopically guided mini-approach, and laparoscopic gastropexy. The grid approach, or mini laparotomy, is the simplest, and it requires no special equipment. Although the other two approaches may improve placement of the gastropexy site, when compared to the grid approach, they should only be performed by experienced surgeons.

Looking Forward

Diagnosis, treatment, and follow up for GDV have improved noticeably over the past few decades. Survival and quality of life

after a GDV episode have increased, and doctors and researchers have new methods for prevention. However, there is still a long way to go. Dogs still die of bloat when they are brought to the emergency room too slowly or when their owners cannot afford expensive surgery or postoperative care.

In order to reduce the impact of GDV on dogs, and their owners, it is critical to educate owners of high-risk breeds about the warning signs of the condition. That way, they can quickly seek out care. Similarly, veterinarians may want to encourage owners of high-risk breeds to look into veterinary health insurance policies that will cover expensive care in times of emergency.

At the same time, researchers need to continue to work to improve their understanding of the etiology of GDV, to learn why it affects some dogs and not others. The more scientists can identify clear, modifiable risk factors for GDV, the easier it will be to prevent.

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