Evaluation of a staged technique of immediate decompressive and delayed surgical treatment for gastric dilatation-volvulus in dogs

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OBJECTIVE

To evaluate a staged technique of immediate decompressive and delayed surgical treatment for gastric dilatation-volvulus (GDV) in dogs.

ANIMALS

41 client-owned dogs with confirmed GDV from 2012 through 2016.

PROCEDURES

Medical record data were collected regarding patient signalment, diagnostic test results, gastric lavage findings, surgical findings, and short-term survival status. For all dogs, gastric decompression was performed by orogastric intubation and gastric lavage in the same anesthetic episode. If this stage was successful, subsequent corrective surgery (laparotomy and gastropexy) was delayed and performed in a second anesthetic episode.

RESULTS

6 dogs underwent corrective surgery in the same anesthetic session as for decompression and stabilization, 2 of which had gastric necrosis. Thirty-five dogs underwent corrective surgery in a second anesthetic episode a mean of 22.3 hours (range, 5.25 to 69.75 hours) after presentation, during which gastric necrosis was identified in 2 dogs. The mortality rate for delayed-surgery patients was 9% (3/35). Time from presentation to surgery was not associated with surgeon subjective assessment of gastric health status or mortality rate. Intraoperative identification of gastric necrosis was associated with nonsurvival. Single plasma lactate concentrations and percentage change in serial lactate concentrations were associated with intraoperative gastric health status and mortality rate.

CONCLUSIONS AND CLINICAL RELEVANCE

The observed mortality rate for delayed-surgery patients was comparable to rates reported for other GDV treatment techniques. Results suggested that delaying corrective surgery is possible for certain dogs, but careful case selection would be important and no reliable preoperative case selection criteria were identified. Additional research is needed to further investigate the potential risks and benefits of staged versus immediate surgical treatment of GDV in dogs. (*J Am Vet Med Assoc* 2021;258:72–79)

Gastric dilatation-volvulus in dogs can quickly lead to shock, cardiac arrhythmia, myocardial dysfunction caused by compression of intra-abdominal veins, and reduced venous return secondary to the dilatation.[1–6] Increased intra-abdominal pressure secondary to GDV also decreases total thoracic volume and prevents full inflation of the lungs, further exacerbating the effects of hindered perfusion.[6] Cardiovascular and respiratory compromise progressively worsen and can contribute to the development of lactic acidosis, gastric necrosis, thrombosis, and disseminated intravascular coagulation and a greater risk of morbidity or death the longer the GDV remains untreated.[1–4,6–11,a] Therefore, resolution of GDV and the associated shock state should be accomplished as soon as possible to allow for the best prognosis for recovery.[1,6,7,a]

Definitive treatment of GDV includes decompression and derotation of the stomach, inspection of gastric tissue, and surgical stabilization to reduce the risk of recurrence. These treatment goals can be accomplished at the same time during an immediate emergency laparotomy, and the general consensus appears to be that surgical treatment of GDV should be performed as soon as possible.[1,2,7,8,10,12,a] Nevertheless, some research[2,7,8,10,12–16,a] suggests that immediately taking dogs to surgery after GDV is diagnosed may not be in the best interest of every patient. Indeed, there is a paucity of research specifically focused on how soon after diagnosis surgery should be performed.

Our hospital's approach to the treatment of GDV is somewhat unusual in that it is staged, with 2 anesthetic episodes, to first resolve the gastric dilatation

ABBREVIATIONS

aPTT	Activated partial thromboplastin time
CRI	Constant rate infusion
GDV	Gastric dilatation-volvulus
PT	Prothrombin time
PTT	Partial thromboplastin time
SIRS	Systemic inflammatory response syndrome

through gastric decompression followed by recovery from anesthesia and a period of medical stabilization, then to surgically inspect and stabilize the stomach similarly to existing protocols.[13–16] Such staging of GDV treatment serves to both correct the source of the shock state associated with GDV and allow some period for fluid resuscitation, monitoring, and stabilization prior to corrective surgery. The purpose of the study reported here was to evaluate this staged treatment technique and compare short-term outcomes with those previously reported for traditional treatment techniques involving immediate surgery. We anticipated that staged GDV treatment would yield patient outcomes and mortality rates similar to or better than traditional treatment techniques.

Materials and Methods

Case selection criteria

Medical records of dogs with confirmed GDV that were presented to the VCA Emergency Animal Hospital & Referral Center in San Diego, from January 2012 through December 2016, were retrospectively reviewed. Dogs were included in the study if the medical record contained a diagnosis of GDV as confirmed by physical examination and diagnostic imaging, an indication that gastric decompression with gastric lavage had been performed, a written surgery report for an exploratory laparotomy, and time-stamped treatment sheets and laboratory test result forms. Survival to hospital discharge was not required for inclusion; however, dogs euthanized prior to exploratory laparotomy were excluded because definitive findings about gastric health could not be determined.

Medical records review

Patient records were reviewed to gather information on signalment (breed, age, sex, and neuter status); stomach contents as recovered by means of gastric lavage (when recorded); position of the stomach on abdominal radiographs obtained after gastric lavage; position and apparent health of gastric tissue at the time of laparotomy; whether a splenectomy was performed; postoperative complications, including regurgitation and aspiration pneumonia; and laboratory test results. Specific laboratory tests of interest included plasma lactate concentration and blood gas analyses, CBC, serum biochemical analyses, and coagulation tests (PT, PTT, aPTT, and proteins invoked by vitamin K absence), depending on the laboratory equipment available at the time of hospital admission. The selection and timing of laboratory tests performed on intake and during subsequent hospitalization were not standardized and were based on individual clinician preference. Histologic findings for any collected biopsy specimens were excluded from analysis because of inconsistent sample collection sites and frequencies.

Surgical treatment was considered delayed if decompressive and surgical treatment were performed in different anesthetic episodes and immediate if performed during the same anesthetic episode. Time points during specific treatment phases were standardized, as follows. Time of presentation was defined as the first hourly time slot filled in on a patient's treatment sheet. This time point would have involved a rectal temperature, heart rate, and respiratory rate recording, at minimum. Time of discharge was defined as the last hourly slot filled in on a patient's treatment sheet. Time of lavage was defined as the start time of the anesthetic session for gastric lavage (ie, from the time when induction agents were recorded as being administered or, when this time was not specifically recorded, from the first time noted on the anesthesia monitoring sheet). Anesthesia monitoring sheets allowed for recording of vital signs and anesthetic parameters every 5 minutes after the start of anesthesia. Time of surgery was defined as the time when "surgery start" or something similar was noted on the anesthesia monitoring sheet. Time of laboratory value determination was defined as the time a laboratory test was completed or the hour slot when the result was recorded on the patient's treatment sheet. Times from presentation to lavage, presentation to surgery, and presentation to discharge were also recorded on the basis of the aforementioned definitions. Time from onset of clinical signs as observed by the owner to presentation to the emergency clinic was excluded from the study owing to inconsistent recording of this information.

All time measurements recorded in minutes were rounded to the nearest quarter hour (rounded down from 1 to 7 minutes and rounded up from 8 to 15 minutes). Because of the nature of the treatment sheets used, time measurements assigned to an hour slot and not associated with a more specific time stamp were rounded to the nearest hour. The timing of any laboratory value determinations (most commonly, plasma lactate concentrations) that were recorded on the treatment sheet and lacked a separate time-stamped laboratory results form was also rounded to the nearest hour.

Decompression and stabilization protocol

The staged treatment protocol was initiated for all dogs included in the study at the time of initial presentation. Initial stabilization was provided by rapid IV administration of crystalloid fluid and decompression of the stomach by placement of an orogastric tube, followed by gastric lavage. Trocarization of the stomach was performed in some dogs as part of initial decompression or to facilitate orogastric tube placement. Selection of specific analgesics and anesthetics for stabilization and gastric lavage was not standardized but generally followed the same anesthetic plans. Plans for gastric lavage procedures and subsequent exploratory laparotomies included IV administration of an opioid (hydromorphone at 0.1 mg/kg [0.045 mg/lb], methadone at 0.2 to 0.3 mg/kg [0.09 to 0.14 mg/lb], morphine at 0.05 mg/kg [0.023 mg/lb], or butorphanol tartrate at 0.1 to 0.2 mg/kg), with or without midazolam (0.2 mg/kg) or acepromazine maleate (1 to 8 µg/kg [0.45 to 3.6 µg/lb]) as premedication; induction with propofol (administered IV to effect) or a combination of ketamine hydrochloride (5 to 10 mg/kg [2.3 to 4.5 mg/lb]) and diazepam (0.25 mg/kg [0.11 mg/lb]); maintenance with isoflurane; and intraprocedural IV administration of crystalloid fluid. Antimicrobials administered during lavage and laparotomy procedures included single doses of cefazolin sodium (22 mg/kg [10 mg/lb], IV) or ampicillin-sulbactam (30 mg/kg [13.6 mg/lb], IV).

For dogs in which orogastric intubation and gastric lavage were successful, abdominal radiography was used to determine the size and position of the stomach after decompression and identify any other intra-abdominal abnormalities. The position of the stomach after decompression was considered normal (no volvulus) or abnormal (ie, with some degree of volvulus remaining) on the basis of the radiographic findings recorded in the medical record. For dogs that underwent radiography but lacked recorded findings, the abdominal radiographs (if available) were reviewed by the primary author (RSW), who classified the stomach position as normal or abnormal.

If decompression was deemed successful, dogs were allowed to recover from anesthesia and medical stabilization was continued over a period of several hours prior to exploratory laparotomy. Such stabilization included continuation of IV fluid, analgesic, antimicrobial, and antacid administration, chosen on the basis of clinician preference. During this period, and after gastric lavage, several patient variables were monitored to gauge the dog's response to decompression and stabilization. These variables were not measured for all dogs but generally included findings of serial physical examinations (including rectal temperature, heart rate, respiratory rate, capillary refill time, and arterial blood pressure), serial abdominal circumferential measurements or other estimations of abdominal size to monitor for recurrence of gastric dilatation, repeated abdominal radiography if recurrence of gastric dilatation was of concern, and serial laboratory tests when deemed appropriate by the attending clinician.

If at any phase of stabilization or decompression there was a concern for sepsis or the presence of gastric necrosis, adequate decompression by orogastric tube placement and gastric lavage could not be completed (eg, the orogastric tube could not be passed into the stomach despite multiple attempts), or stabilization could not be achieved despite the described treatment protocol, immediate exploratory laparotomy was recommended. In such cases, the anesthesia provided for the gastric lavage procedure was maintained, the dog was moved into an operating room for laparotomy, additional opioid analgesics were provided as needed (primarily in situations when butorphanol had been used as premedication for gastric lavage), and previously IV administered antimicrobials were readministered every 90 minutes of procedure time.

Surgical protocol

For dogs allowed to recover from anesthesia after decompression and stabilization, laparotomy and subsequent gastropexy were generally performed the morning after hospital admission, although in some cases the procedure was delayed for a longer period at the discretion of the attending clinician or per owner request. For all dogs, including those immediately undergoing laparotomy, the stomach was examined and derotated or decompressed if necessary. After exploration was complete, gastropexy was performed in a nonstandardized manner, with the chosen technique at the discretion of the attending surgeon.

Postoperative analgesic, antimicrobial, antacid, and anti-arrhythmic treatments were not standardized and were provided at the discretion of the attending clinician. After recovering from surgery, patients were hospitalized until they were deemed ready for discharge by the managing clinician. If elected at any time during hospitalization, euthanasia was performed by IV injection of pentobarbital-based euthanasia solution.

Owing to inconsistent data recording, the exact degree of gastric rotation found during laparotomy was not included as a study variable; instead, this information was recorded for study purposes as normal or abnormal. Gastric health data were collected and considered as described in the surgery report (ie, the surgeon's subjective assessment of the tissues), then classified as mild bruising, moderate bruising, or necrotic as reported previously.[9] Most surgery reports included 1 of these 3 descriptions verbatim, but when no such descriptions were used or the descriptions were used in combination, gastric health status was recorded as the next worst descriptor (eg, minimal bruising was coded as mild bruising).

Statistical analysis

Linear regression was performed to evaluate associations among numeric or continuous variables, and ANOVA was used to evaluate associations between numeric or continuous variables and categorical or nominal variables. When categorical or nominal variables contained > 2 subgroups and a significant ($P < 0.05$) association was noted, the Fisher-protected least significant difference test was used to identify the specific pairs of subgroups that differed significantly. The χ^2 test was used to evaluate associations among categorical or nominal variables. For all analyses, statistical software[b] was used and values of $P < 0.05$ were considered significant.

Results

Animals

The medical records for 73 dogs with GDV were analyzed for potential inclusion in the study. Of the 73 dogs, 14 were excluded because of incomplete medical records or because orogastric intubation was not included as part of gastric decompression. Eighteen dogs were transferred to another veterinary hospital for corrective surgery or were discharged per owner request without corrective surgery after decompression and stabilization had been achieved. Those dogs were also excluded, leaving 41 dogs for inclusion in the study.

The 41 dogs included 20 (49%) castrated males, 8 (20%) sexually intact males, and 13 (32%) spayed females. Mean age at time of presentation was 7.1 years (range, 1 to 13 years). The most commonly represented breeds were German Shepherd Dog (n = 8 [20%]), Standard Poodle (6 [15%]), Labrador Retriever (4 [10%]), and Great Dane (3 [7%]). No significant associations were identified between patient breed, age, sex, or neuter status and survival to hospital discharge (yes or no).

Treatment

Only 6 of 41 (15%) dogs underwent corrective surgery (laparotomy and gastropexy) during the same anesthetic session as for decompression by means of orogastric tube placement and gastric lavage. These dogs were immediately taken to surgery because of an inability to pass the orogastric tube (n = 3), decline into cardiac arrest during gastric lavage (1), hemorrhagic gastric lavage contents with concern for necrosis (1), and owner-requested immediate surgery (1). For the remaining 35 (85%) dogs, the mean time from presentation to surgery was 22.3 hours (range, 5.25 to 69.75 hours). Time from presentation to surgery was not associated with gastric health status at the time of laparotomy ($P = 0.25$) or survival to discharge ($P = 0.14$).

A gastropexy was performed in 36 dogs, 15 of which underwent belt-loop gastropexy and 21 of which underwent incisional gastropexy. Surgeries were performed by several veterinarians including board-certified surgeons and non–board-certified emergency surgeons. Additional procedures were performed in 15 patients at the time of exploratory laparotomy and gastropexy, all of which were performed in patients with delayed surgery. These procedures included collection of liver biopsy specimens (n = 11), collection of gastrointestinal biopsy specimens (7), splenectomy for splenic nodules or damage secondary to splenic torsion (3), dermal mass removal (2), cholecystectomy for cholecystolithiasis and concern for biliary obstruction (1), cystotomy for cystic calculi seen on abdominal radiographs (1), and gastrotomy for a gastric foreign body (1).

Surgical, radiographic, and clinicopathologic findings

Of the 32 dogs for which gastric lavage contents were recorded, 24 (75%) had no evidence of hemorrhage and 8 (25%) had contents described as hemorrhagic. Hemorrhagic gastric lavage contents were not significantly associated with gastric health status at laparotomy ($P = 0.32$) or survival to discharge ($P = 0.38$). Of the 35 dogs that were not immediately taken for surgery, 14 (40%) had a radiographically normal stomach position (ie, no volvulus) and 21 (60%) had a radiographically abnormal stomach position (ie, some degree of volvulus remaining) after orogastric intubation and gastric lavage. At laparotomy, 20 of those 35 (57%) dogs had a normal gastric position and 15 (43%) had an abnormal gastric position. In comparisons of postlavage radiographic and surgical findings, 10 of 35 (29%) dogs had a normal stomach position for both, 9 (26%) had resolution of gastric volvulus between postlavage radiography and laparotomy, 4 (11%) had recurrence of gastric volvulus after resolution between postlavage radiography and laparotomy, and 12 (34%) maintained an abnormal gastric position from the time of presentation to surgery. For the 35 patients that underwent the staged protocol, no association was identified between stomach position at the time of postlavage radiography and position at the time of surgery ($P = 0.10$). At neither point was stomach position associated with survival status ($P > 0.67$). Although stomach position at postlavage radiography was not associated with gastric health status ($P = 0.13$), an abnormal stomach position at laparotomy was associated with worse gastric health status ($P = 0.02$).

Initial plasma lactate concentration was recorded for 38 dogs for a mean value of 3.7 mmol/L (range, 1.2 to 11.1 mmol/L). Higher values were significantly ($P < 0.001$) associated with worse gastric health status at laparotomy. Specifically, significant differences in plasma lactate concentrations were identified between dogs with mildly bruised and necrotic tissue ($P < 0.001$) and between dogs with moderately bruised and necrotic tissue ($P < 0.001$), but not between dogs with mildly and moderately bruised tissue ($P = 0.73$). Higher initial plasma lactate concentrations were also associated with hemorrhagic gastric lavage contents ($P = 0.04$) and nonsurvival ($P < 0.001$). Nonsurvivors had a mean initial plasma lactate concentration of 7.3 mmol/L (range, 2.7 to 11.1 mmol/L), whereas survivors had a mean concentration of 3.2 mmol/L (range, 1.2 to 7.8 mmol/L).

Serial measurements of plasma lactate concentration, including at least 1 measurement before and 1 after decompression and stabilization, were recorded for 22 dogs. Of these dogs, 18 (82%) had an initial value > 2.0 mmol/L. Two of the 18 dogs had gastric necrosis, and their plasma lactate concentration decreased by 49.5% and 27.4% from before to after decompression and stabilization. One of the 18 dogs had a plasma lactate concentration that decreased by 58.2%, moderate gastric bruising, and concurrent colonic torsion with concern for colonic necrosis, prompting intraoperative euthanasia. The remaining 15 dogs had mildly to moderately bruised gastric tissue identified at laparotomy, and all but 1 dog had a decrease in plasma lactate concentration of 50% from before to after decompression and stabilization. Larger percentage decreases in plasma lactate concentrations were associated with better gastric health status ($P = 0.03$) and a higher likelihood of survival to discharge ($P = 0.03$).

Outcome

Overall, 36 of 41 (88%) dogs survived to hospital discharge. Four of the 6 (67%) dogs that underwent immediate surgery survived to discharge, and 32 of the 35 (91%) dogs that underwent the staged protocol survived to discharge. The 5 patients that did not survive to discharge were euthanized owing primarily to health concerns (and not financial concerns).

Gastric health status was significantly ($P < 0.001$) associated with survival status. All 25 dogs with mild gastric bruising survived. Eleven of 12 dogs with moderate bruising survived, with the 1 nonsurvivor euthanized intraoperatively owing to concurrent colonic torsion.

In total, 4 dogs had necrotic gastric tissue, and all 4 were euthanized intraoperatively owing to a poor prognosis as perceived by a board-certified veterinary surgeon. For 2 dogs with gastric necrosis, decompression and stabilization were performed and then surgery was delayed until the following day, whereas the other 2 dogs were transitioned immediately to surgery after initial stabilization because of hemorrhagic gastric lavage contents (n = 1; dog 1) or cardiac arrest during anesthesia for gastric lavage (1; dog 2). The gastric necrosis in dog 1 involved 75% of the stomach, from the fundus orally beyond the level of the cardia. This patient had a prolonged thrombotest result (30 seconds; reference interval, 15 to 20 seconds) and shortened aPTT (64 seconds; reference interval, 72 to 102 seconds) but was fairly stable during anesthesia. The extent and location of gastric necrosis were the primary concerns prompting euthanasia. The gastric necrosis in dog 2 involved 60% to 70% of the stomach, primarily affecting the pyloric antrum and distal stomach region. This patient also had a prolonged PT (65 seconds; reference interval, 11 to 17 seconds) and aPTT (216 seconds) and hypoglycemia (blood glucose concentration, 58 mg/dL; reference interval, 60 to 110 mg/dL) and remained hemodynamically unstable while anesthetized despite administration of epinephrine, atropine, dopamine, and hypertonic saline solution and transfusions with fresh frozen plasma. For dog 2, the extent and location of gastric necrosis combined with anesthetic instability were the primary concerns prompting euthanasia.

In 1 of the 2 dogs with gastric necrosis for which corrective surgery was delayed, decompression was successful with no evidence of hemorrhage on gastric lavage, but preoperative stabilization was challenging and the position of the stomach was abnormal throughout the stabilization process. Initial plasma lactate concentration was 9.9 mmol/L (reference interval, 0.6 to 2.0 mmol/L), which decreased by 46.5% to 5.3 mmol/L soon after decompression and another 10.1% to 4.3 mmol/L (an overall decrease of 56.6%) after additional IV fluid administration. Initial blood glucose concentration at presentation was 46 mg/dL, and IV dextrose administration was initiated. Non–fluid-responsive hypotension persisted after decompression; therefore, a dopamine CRI was initiated until hypotension resolved, after which the CRI was discontinued. Prolonged clotting times were observed, including a PT that exceeded the upper limit of detection (ie, > 120 seconds) and aPTT of 180 seconds, so a transfusion of fresh frozen plasma was initiated. After transfusion, the PT improved to 29 seconds and aPTT remained prolonged at 183 seconds. At that point, 11 hours after presentation and 8.75 hours after gastric lavage, the patient was prepared for laparotomy despite remaining in critical condition. During surgery, gastric necrosis affecting approximately 60% of the stomach was identified, involving primarily the cardia and some of the fundus. The liver and gallbladder were described in the surgery report as abnormal with limited additional details, but a cholecystectomy was recommended, and the dog developed severe bradycardia and hypotension. For that dog, the extent and location of gastric necrosis combined with anesthetic instability and potential need for additional high-risk procedures were the primary concerns prompting euthanasia.

The second dog for which corrective surgery was delayed had an initial plasma lactate concentration of 2.7 mmol/L, and no additional lactate concentration measurements were obtained, the reason for which could not be surmised from the record. This patient had no disconcerting examination findings other than appearing more sedate than anticipated following anesthesia for gastric lavage, and no evidence of hemorrhage was noted in the gastric lavage contents. However, the position of the stomach as it appeared in postlavage radiographs and at the time of laparotomy was noted to be abnormal, suggesting that some degree of volvulus remained after decompression. During laparotomy, approximately 80% of the stomach including the cardia and fundus appeared necrotic, and the extent and location of this necrosis were the primary concerns prompting euthanasia. Gastric lavage was performed 2.5 hours after presentation, and surgery was delayed until the following afternoon, 15.5 hours after presentation. An explanation for the length of the surgical delay could not be determined from the medical record.

Overall, 3 of 41 (7%) dogs had postoperative regurgitation and 2 (5%) developed aspiration pneumonia. No significant association was identified between timing of surgery (immediate or delayed) and postoperative regurgitation ($P = 0.74$) or development of aspiration pneumonia ($P = 0.71$). A longer time between presentation and surgery was associated with a longer hospitalization period ($P = 0.009$) and higher financial cost ($P = 0.03$). None of the dogs that survived to discharge from the hospital were discharged against medical advice.

Discussion

Results of the present study suggested that successful decompression and stabilization prior to surgical correction of GDV in dogs may allow for surgery to be delayed in selected cases. From the available data, no specific preoperative patient characteristics were identified that might help predict which dogs might tolerate and benefit from a staged treatment approach or whether gastric necrosis was present.

The mortality rate of dogs that underwent the staged protocol was 9%, which was similar to other mortality rates reported for dogs undergoing immediate surgical correction of GDV (7.5% to 18%).[7,10,17–19] In the present study, all 4 dogs with gastric necrosis were euthanized at the time of laparotomy because of the extent and location of gastric necrosis and, for 2 dogs, comorbidities. This unusually high mortality rate for dogs with gastric necrosis, compared with rates in other studies, was likely attributable to the lack of patients undergoing partial gastrectomy. Additional research is warranted into outcomes of the staged technique for dogs with gastric necrosis undergoing partial gastrectomy.

No association was identified between survival of the study dogs to discharge and time from presentation to surgery, but this should be considered in the context of GDV and its sequelae. The primary concern regarding a prolonged time from presentation to surgery is the potential for development of gastric necrosis, which is a possible sequela of GDV that has been consistently linked to a poorer prognosis and higher perioperative mortality rate.[1,7,9,10,13,18–21,a] Because of the association between poor prognosis and gastric necrosis, considerable effort has been spent investigating whether certain preoperative laboratory or examination findings are associated with gastric necrosis. Factors previously identified as associated with poor prognosis in dogs with GDV include abnormal CBC results,[1,9,a] coagulation profiles,[1,9,11,a] plasma ionized calcium concentration,[5,a] single and serial serum lactate measurements,[1,17,18,22] patient demeanor at presentation,[7,23] and gastric lavage contents[1,12,13,a] and older age.[1,7] Several of these factors have also been associated with gastric necrosis,[1,9,17,20] but no definitive preoperative findings have been identified that consistently predict the presence of this abnormality.

In the present study, high initial plasma lactate concentration was associated with worse gastric health status (as subjectively assessed) and the likelihood of nonsurvival. In a previous study,[17] an initial plasma lactate concentration[3] of 6 mmol/L was associated with a significant increase in mortality rate, whereas results of other studies[20,22] indicate that serial measurements of plasma lactate concentration before and after decompression and fluid resuscitation may be more useful. Our findings suggested that serial measurements may be of more value than a single measurement, given that one dog with an initial plasma lactate concentration of 2.7 mmol/L had severe gastric necrosis and another dog with an initial concentration of 7.8 mmol/L had only mild gastric bruising. Additionally, it appeared that greater percentage decreases in plasma lactate concentrations after decompression were associated with healthier gastric tissue and a higher likelihood of survival to discharge, supporting the usefulness of serial lactate measurements before and after decompression when considering the prognosis for dogs with GDV. Given the nonstandardized diagnostic protocol before and after decompression and stabilization, no conclusions could be drawn from the present study regarding whether plasma lactate concentration would be useful for identifying patients that would or would not tolerate a delay to corrective surgery.

Results of previous studies[1,2,8,10,12,a] have suggested that evaluation of gastric lavage contents can potentially provide prognostic information about the presence of gastric necrosis, but to the authors' knowledge, the present study was the first to investigate that possibility statistically. The presence of blood, black digested blood, or sloughed tissue could conceivably signal more severe or chronic gastric damage, but we found no significant association between gastric lavage contents as obtained during decompression and gastric health status. Neither of the 2 dogs with gastric necrosis for which surgery was delayed had evidence of hemorrhage in their gastric lavage contents, but gastric lavage was not performed again prior to surgery, so it remains unknown whether hemorrhage might have occurred before surgery. Serial examination of gastric lavage contents throughout stabilization may be of more benefit than the single examination at the time of initial decompression. The inconsistent and variable descriptions of gastric lavage contents in the medical records could have also led to misclassification, further obscuring any relationship that might have existed between hemorrhagic gastric lavage contents and gastric health status.

Several techniques have been reported for decompression of the stomach and stabilization of dogs with GDV prior to and during surgery,[1,2,8,12,14,16,24] including some that allow for maintenance of decompression.[8,14,24] Orogastric intubation and gastric lavage with or without trocarization were the only decompressive techniques used in the present study because our experience suggested these techniques can quickly eliminate and allow inspection of gastric contents and reduce the degree of gastric dilatation. A 25% failure rate was reported for orogastric intubation in dogs with GDV in a previous study,[2] preventing adequate decompression. In the present study, only 7% (3/41) of records included descriptions of complete inability to pass an orogastric tube despite multiple attempts and its combination with trocarization, suggesting that orogastric intubation and trocarization together may be more successful than orogastric intubation alone.

An important disadvantage of the staged technique evaluated in the present study is that definitive resolution of volvulus is delayed until laparotomy, which may prolong the period during which gastric perfusion is compromised. Experimental induction of gastric dilatation without volvulus and gastric volvulus without dilatation has been performed to explore each component of GDV (ie, dilatation and volvulus) separately.[25,26] Gastric dilatation alone results in a clinical progression and intra-abdominal findings similar to those of dilatation with volvulus,[25] highlighting the importance of gastric decompression in disease progression. More importantly to the present study, however, a previous study[26] showed that induction of 360° volvulus without dilatation in healthy dogs can compromise venous drainage and contribute to edema and hemorrhage in as little as 4 hours and necrosis in 12 hours after induction. Clearly, timely resolution of both dilatation and volvulus is important for reducing the risk of developing gastric necrosis.

Although the aim of preoperative gastric decompression techniques is to directly address the dilatation, such techniques may also indirectly address volvulus to some degree. In a previous study,[2] with partial relief of gastric dilatation achieved by trocarization alone, some dogs (6/39 [15%]) with confirmed GDV at hospital admission no longer had volvulus at the time of exploratory laparotomy. In the present study, 40% (14/35) of patients had apparent radiographic resolution of volvulus after gastric lavage, and 49% (20/41) had resolution of volvulus at the time of laparotomy, representing a resolution rate for preoperative gastric volvulus higher than previously reported. This suggested that preoperative treatment aimed at gastric decompression could accomplish resolution of both dilatation and volvulus before surgery in some patients, at least temporarily. Nevertheless, such treatment would by no means guarantee that stomach position would return to normal (ie, no volvulus) following decompression, as evidenced by 34% of dogs in which at least some degree of volvulus was maintained after decompression, or that volvulus would not recur if the stomach was initially found in a normal position, as evidenced by the 11% of dogs in which volvulus recurred prior to surgery. Decompression also does not eliminate the need for surgical inspection, derotation if needed, and surgical stabilization. However, our findings suggested that some dogs may be able to tolerate longer intervals between decompression and surgery than others, presuming sufficient perfusion to the stomach is restored after even partial resolution of volvulus. Of note, 1 dog in the present study had had a GDV episode 10 months prior to the episode that qualified it for inclusion, and although decompression was successful both times, surgical exploration and gastropexy were declined by the owner during the first episode but elected during the second episode. According to a previous study,[16] dogs can go several months without recurrence of GDV after successful decompression of the stomach by gastric lavage without subsequent gastropexy, and 1 dog went almost 2 years without a recurrence. This supported the argument that, as long as decompression is successful and gastric tissue remains sufficiently perfused, some patients can wait for definitive surgical treatment of GDV and have good short-term outcomes. The factors that render certain patients good candidates for delayed surgical intervention remain to be determined.

Because some dogs with GDV go on to develop gastric necrosis despite decompression and stabilization efforts, full assessment of each case and individualization of treatment plans must be performed without presuming good outcomes will follow this first stage. No reliable preoperative predictors of gastric necrosis were identified that might assist in predicting which dogs with GDV are at risk, so surgical inspection remains the most reliable test available for diagnosis of gastric necrosis. Until preoperative tests for gastric necrosis are identified, delaying surgery cannot be widely recommended, and the staged technique described herein should be considered with this in mind. Another consideration would be the need for 2 anesthetic episodes with the staged technique, thereby potentially increasing the risk of anesthetic complications. In the present study, 5% (2/41) of dogs developed aspiration pneumonia during hospitalization, which is an incidence higher than previously reported (0% [0/116]) for preoperative decompression protocols[2] and could suggest that our staged technique increased the risk of aspiration pneumonia.

The ideal stabilization period for dogs with GDV before corrective surgery remains unclear. The mean time from presentation to surgery for dogs in which corrective surgery was delayed was 22.3 hours, suggesting that most dogs underwent exploratory laparotomy and gastropexy the day after presentation. Overall, for dogs with longer delays from presentation to surgery, the hospitalization period was longer and financial costs were greater. Additional research is needed to determine whether hospitalization periods and financial costs differ between dogs with GDV undergoing immediate versus staged decompression and surgery.

A limitation of the present study was that the timing of events included in the analysis was determined on the basis of hourly time stamps on treatment sheets and thus represented approximations. Additionally, none of the dogs underwent gastric resection, so results cannot be extrapolated to dogs treated in that manner. Furthermore, no long-term follow-up information was collected, and no conclusions could be drawn regarding long-term outcomes and complications.

Despite the aforementioned limitations, results of the study reported here suggested that dogs can tolerate the described staged approach to GDV treatment, with good outcomes and a mortality rate comparable to previously reported rates. Provided that gastric decompression is adequate, stabilization is successful, no gastric necrosis is present, and owners are counseled about the uncertainties that remain regarding the described staged approach, this technique may be useful when owners are reluctant to pursue or are unable to afford immediate surgery, immediate surgery cannot be performed, or transfer from one medical facility to another is required. Immediate decompression and stabilization of patients could give these patients valuable time, potentially reducing the risk of gastric necrosis and improving the chance of survival. Nevertheless, the staged technique may pose a risk of aspiration pneumonia and be more expensive than traditional immediate surgical techniques. Furthermore, no reliable preoperative case selection criteria were identified to help determine which patients might benefit from a staged approach. Additional research is needed to further investigate the potential risks and benefits of staged versus immediate surgical treatment of GDV in dogs.

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Footnotes

a. Thongkorn K. *A 6-year retrospective study of canine gastric dilatation-volvulus treated with incorporating gastropexy.* Dr Med Vet dissertation, Freie Universität Berlin, Berlin, Germany, 2012.
b. Systat 5.0, SAS Inc, Cary, NC.

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