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A 6-year Retrospective Study of Canine Gastric Dilatation-Volvulus Treated with Incorporating Gastropexy

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Abbreviations

µg	Microgram
Alb	Albumen
ALT	Alanine Aminotransferase
AP	Alkaline Phosphatase
aPTT	Activated Partial ThromboplastinTtime
AST	Aspartate Aminotransferase
AT III	Antithrombin III
BID	Twice a Day (bis in die)
Bili	Bilirubin
bpm	Beat per Minute
BUN	Blood Urea Nitrogen
Ca	Calcium
Ca++	Ionized Calcium
CBC	Complete Blood Count
Cho	Cholesterol
CK	Creatine Kinase
cm	Centimeter

df	Degree of Freedom
DIC	Disseminated Intravascular Coagulopathy
EKG/ECG	Electrocardiogram
GA	Gauge
GD	Gastric Dilatation
GDV	Gastric Dilatation-Volvulus
GLDH	Glutamate Dehydrogenase
Glu	Glucose
h	Hour
IBD	Inflammatory Bowel Disease
IM	Intramuscular
IV	Intravenous
K	Potassium
kg	Kilogramm
MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Corpuscular Haemoglobin Concentration
MCV	Mean Corpuscular Volume
Mg	Magnesium
mg	Milligramm
min.	Minute

ml	Milliliter
mm	Millimeter
mmol/L	Millimoles/liter
MRSA	Methicillin-Resistant *Staphylococcus aureus*
Na	Sodium
OR	Odd Ratio
P	Phosphorus
PASW	Predictive Analytics Software
PCV	Packed Cell Volume
PO	Per os
Pro	Protein
PT	Prothrombin Time
PVCs	Premature Ventricular Contractions
q	Every (quaque)
QID	Four Times a Day (quater in die)
RBC	Red Blood Cell
SC	Subcutaneous
SID	Once a Day (semel in die)
TDWRs	Thoracic Depth and Width Ratios
TID	Three Times a Day (ter in die)

VES	Ventricular Extrasystoles
WBC	White Blood Cell
χ^2	Chi-square

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1. Introduction

Gastric dilatation (GD) alone and gastric dilatation-volvulus (GDV) are acute, life-threatening syndromes of multifactorial origins that require immediate appropriate medical and surgical treatment as well as intensive postoperative care. Despite proper medical and surgical treatment, overall mortality rates range from 15% to 68% (BROCKMAN et al. 1995; BROURMAN et al. 1996; GLICKMAN et al. 1997; GLICKMAN et al. 1998; KOVACEVIC et al. 2005; PASS et al. 1973; GLICKMAN et al. 2000; BADYLAK et al. 1990).

Acute canine GDV has been recognized and diagnosed for many years, nevertheless the exact etiology is still not clearly recognized. Many studies have shown multiple risk factors for GDV. They include breed, anatomy, genetics, age, feeding, activities, behaviors and other factors. Large and giant breeds of dogs have higher risks of GDV. Breeds significantly ($P<0.001$) overrepresented are the German Shepherd (28.6%) and the Great Dane (17%), compared with the general hospital population (8% and 1%, respectively) (TALI et al. 2007). Anatomically, breeds with higher average thoracic depth/width ratios (TDWRs) are at greater risk of developing GDV than comparably sized breeds with lower average TDWRs (Schaible et al. 1997). HALL et al. (1995) concluded that the length of hepatogastric ligament in GDV-affected dogs was longer than that of clinically normal control dogs. Genetic factors are believed to have an influence on developing GDV. Many studies have shown that older dogs have higher incidences of GDV than younger (MEYER-LINDENBERG et al. 1993; BROCKMAN et al. 1995; DE PAPP et al. 1999; BECK et al. 2006 and BUBER et al. 2007). Inappropriate feeding of dogs can also cause GDV. RAGHAVAN et al. (2004) indicated that feeding dogs a larger volume of food per meal, regardless of the number of meals fed per day, significantly increased their risks of GDV nearly twofold. Vigorous exercise on a full stomach may cause GDV. It is therefore important to inform the owners of these risk factors. Temperament is also a factor associated with a risk of GDV. Nervous, anxious, or fearful dogs tend to be at an increased risk of developing GDV. Additionally, previous studies (GREENFIELD et al. 1989; HALL et al. 1989 and HALL 1989) have cited increased gastrin levels, decreased stomach motility, and delayed gastric emptying to be negative risk factors of GDV.

Diagnosis is based on history, signalment and clinical signs. Common clinical signs include unproductive vomiting, retching, hypersalivation, and distended abdomen. Radiographic confirmation should be performed only after the dog has been decompressed and stabilized. A right lateral abdominal radiographic view has been recommended for the best appearance of

GDV. Additional radiographic views (ventrodorsal and left lateral views) should be taken if the first radiographic findings are equivocal.

Surgery should be performed as soon as the GDV dogs have been treated medically and are stable enough to be given general anesthesia. The principal objectives of surgical treatment are decompression and repositioning of the stomach, resection of a possible pathologic gastric wall, and prophylactic permanent gastropexy. There are many methods of surgical gastropexy. They include tube gastropexy, circumcostal gastropexy, muscular flap (incisional) gastropexy, belt-loop gastropexy, incorporating gastropexy, gastrocolopexy, laparoscopic prophylactic gastropexy, and minilaparotomy prophylactic gastropexy.

Incorporating gastropexy is performed routinely in the Small Animal Clinic, Free University of Berlin, Germany, because this technique is technically simple and can be learned and performed easily. This technique takes less surgical time which diminishes the risk of anesthetic complications (MEYER-LINDENBERG et al. 1993).

The objectives of this study are to characterize the clinical course of GDV and to identify prognostic indicators for canine gastric GDV that could affect the survival or mortality rate.

2. Review Literature

2.1 Etiologies of Gastric dilatation-Volvulus (GDV)

The exact causes of GDV are still not clearly understood, there is no specific causal factor that precedes the development of GDV. However, several studies have shown there are many risk factors. The disease probably results from multiple events between risk factors, which in combination finally result in GDV.

Certain large- and giant-breed dogs, dogs with a large thoracic depth-to-width ratio, dogs with lower body condition score, and older animals are at higher risk of developing GDV (GLICKMAN et al. 2000[a]; GLICKMAN et al. 2000[b]; SCHAIBLE et al.1997). These include the Great Dane, the Saint Bernard, the Weimaraner, the Irish Setter, the Gordon Setter, the Standard Poodle, and the Basset Hound. Large, mixed-breed dogs also are at higher risk compared to small, mixed-breed dogs (GLICKMAN et al. 1994; GLICKMAN et al. 1997). Aggressive and bad tempered dogs might be at more risk of GDV.

Types of diet, the quantity of food ingested per meal, speed of eating, the number of meals per day, exercise and stress after meals have been associated with an increased risk of GDV. Ingestion of commercial dry dog food might be the one of multifactors that leads to the development of GDV. However, BURROWS et al. (1985) noted that gastric motility and emptying in healthy, large-breed dogs were not affected by consumption of a cereal-based food. RAGHAVAN et al. (2006) concluded that dried foods containing fats or oils (e.g., sunflower oil, animal fat) among the first four label ingredients predispose high-risk dogs to GDV (2.4 time increase; P=0.01), but soy- or cereal-based ingredients do not. THEYSE et al. (1998) found that Great Danes dogs consuming a diet containing particles of food > 30 mm in size (kibble and/or dinner and/or home-prepared food with large pieces of meat) had a lower risk of GDV than those fed a diet containing only particles of food < 30 mm in size (kibble or dinner and/or canned meat and/or home-prepared food cut into small pieces or ground in a food processor). Dogs fed a larger amount of food per meal were at a significantly (P<0.05) increased risk of GDV, regardless of the number of meals per day. For both large- and giant-breed dogs, the risk of GDV was highest for dogs fed a larger amount of food once a day (RAGHAVAN et al. 2004). Raising the dog's feed bowl is not appropriate for either large- or giant-breed dogs because it may promote aerophagia and increase the risk of GDV (GLICKMAN et al. 2000[a]).

Decreased stomach motility, delayed gastric emptying, and an increased gastrin level have been associated with an increased risk of GDV. Removal of a large spleen especially, a voluminous splenic tumor, has been implicated as a contributory factor in the development of GDV in dogs and they may benefit from concurrent prophylactic gastropexy (MARCONATO 2006).

Fewer studies have investigated if there is a significant association between the occurrence of GDV and climatic conditions. Although temperature was significantly associated with the occurrence of GDV, the difference in temperatures between days with and days without GDV cases was so small that it is unlikely to be of clinical relevance. Besides, no significant association has been found between GDV occurrence and atmospheric pressure or humidity, nor was seasonal variation in GDV incidence observed (DENNLER et al. 2005).

2.2 Pathophysiology of GDV

GDV is an acute life-threatening condition, characterized by the rapid accumulation of air and fluid in the stomach, malpositioning of the stomach, increased intragastric pressure, and often hypovolemic shock, eventually leading to death. The gas probably comes from aerophagia, although bacterial fermentation of carbohydrates, diffusion from the blood stream, and metabolic reactions may contribute. Normal gastric secretion and transudation of fluids into the gastric lumen as a result of venous congestion contribute to fluid accumulation (FOSSUM et al. 2002). Etiopathogenesis of GDV refers to the delayed gastric emptying of solid particles and the laxity of the hepatoduodenal and gastrohepatic ligaments that support the stomach in the right side of the abdomen which normally allow a high degree of gastric mobility (HALL et al. 1995; MONNET 2003). During volvulus, the pylorus and duodenum migrate first ventrally and then cranially. The pylorus moves from right to left and next dorsally on the left side of the body of the stomach. The pylorus is then located dorsal to the esophagus and the fundus on the left side of the abdominal cavity. GDV causes inadequate tissue perfusion, which is associated with severe changes to multiple organs, including the stomach, liver, heart, pancreas, kidneys, and small intestine, ultimately leading to hypovolemic shock and endotoxemia (MONNET 2003). The stomach twist in GDV varies from 90-360 degrees. Gastric pathology ranges from mild edema and hemorrhage in one or more tissue layers, to full thickness necrosis and perforation (STROMBECK and GUILFORD 1991). A retrospective study performed by BRAUN et al. (1996) showed a possible association between GDV and inflammatory bowel disease (IBD). A report on mesenteric volvulus in dogs also noted a possible association with gastrointestinal disease (NEMZECK and WALSHAW, 1993)

2.3 Diagnosis of GDV

2.3.1 Signalment

GDV has been commonly reported in large- and giant-breed dogs (i.e., the Great Dane, the Weimaraner, the Saint Bernard, the German Shepherd, the Irish and Gordon setters, the Doberman pinscher) but it also can be found in small dogs and cats. GLICKMAN et al. (1994) reported that Basset Hounds had the eighth highest risk of GDV (OR 1.4), among all dog breeds. However, they had the highest risk of GDV (OR 31.7) and ranked first within the < 23-kg breed weight category, compared with miniature poodles. HELLWEG AND ZENTEK (2005) showed no correlation between gender and risk of GDV from a total of 882 internet-based questionnaires.

Feline GDV is rare; diaphragmatic hernia has been implicated as a contributory factor in the development of GDV in cats. FORMAGGINI et al. (2008) reported 3 cases of feline GDV associated with diaphragmatic hernia. If feline GDV is concurrent with diaphragmatic hernia, a gastropexy seems unnecessary, as herniorrhaphy eliminates the predisposing factors. On the other hand, if feline GDV occurs without diaphragmatic hernia, then a gastropexy may be indicated. No sex predilection has been demonstrated.

2.3.2 History

Affected dogs typically retch unproductively and may show abdominal pain. A history of a progressively distending and tympanic abdomen may be a sign of GDV. However, abdominal distention is not always obvious in large, heavily muscled, or very obese dogs. The dog may display an arched back, hypersalivation and restlessness. Eventually, depression and a moribund state occur (NELSON and COUTO 2003; FOSSUM et al. 2002). Previous sicknesses of dogs should be concerned because they could be predisposing causes of GDV. Dogs with a history of splenic tumor which had been splenectomized tend to be at risk for developing GDV. GRAMMEL-WEMHEUER et al. (1991) published a case report about complications of GDV in a dog. This dog was diagnosed to have GDV and was operated immediately after it was treated medically. Diaphragmatic hernia was also accidentally found during a corrective operation of GDV. However it appeared to be old hernia because bleeding was not observed. The duodenum was invaginated into the thoracic cavity and the pancreas was in autolysis. They assumed that GDV could be a consequence of diaphragmatic hernia.

2.3.3 Physical examination findings

Abdominal palpation could be uncomfortable due to the abdominal pain. A tympanic sound can sometimes be detected on percussion. Splenomegaly can sometimes be palpated. GDV leads to different degrees of shock so it is very important to recognize all the vital signs during the evaluation of a patient. Clinical signs include weak peripheral pulses, tachycardia, prolonged capillary refill time, pale mucous membrane, cold extremities, or dyspnea (MONNET 2003)

2.3.4 Radiography

The use of radiography in the diagnosis of GDV is widely established. Affected animals should be decompressed before radiographs are taken. Gastric decompression can be performed by a combination of orogastric intubation or needle gastrocentesis. A sedative combination of oxymorphone (0.1 mg/kg, iv) and diazepam (0.5 mg/kg, iv) can be administered to uncoorperative dogs. A right lateral abdominal radiographic view has been recommended for the best appearance of GDV. Additional radiographic views (ventrodorsal and left lateral views) need to be taken if the first radiographic findings are equivocal. A correct radiographic interpretation is necessary to differentiate simple dilatation from dilatation with volvulus (BROCKMAN et al 1995). On the right lateral view of a dog with GDV, the pylorus lies cranial to the body of the stomach and is separated from the rest of the stomach by soft tissue (reverse C-sign). Volvulus is denoted by displacement of the pylorus and/or formation of a “shelf” of tissue in a gastric shadow (Figure 1).

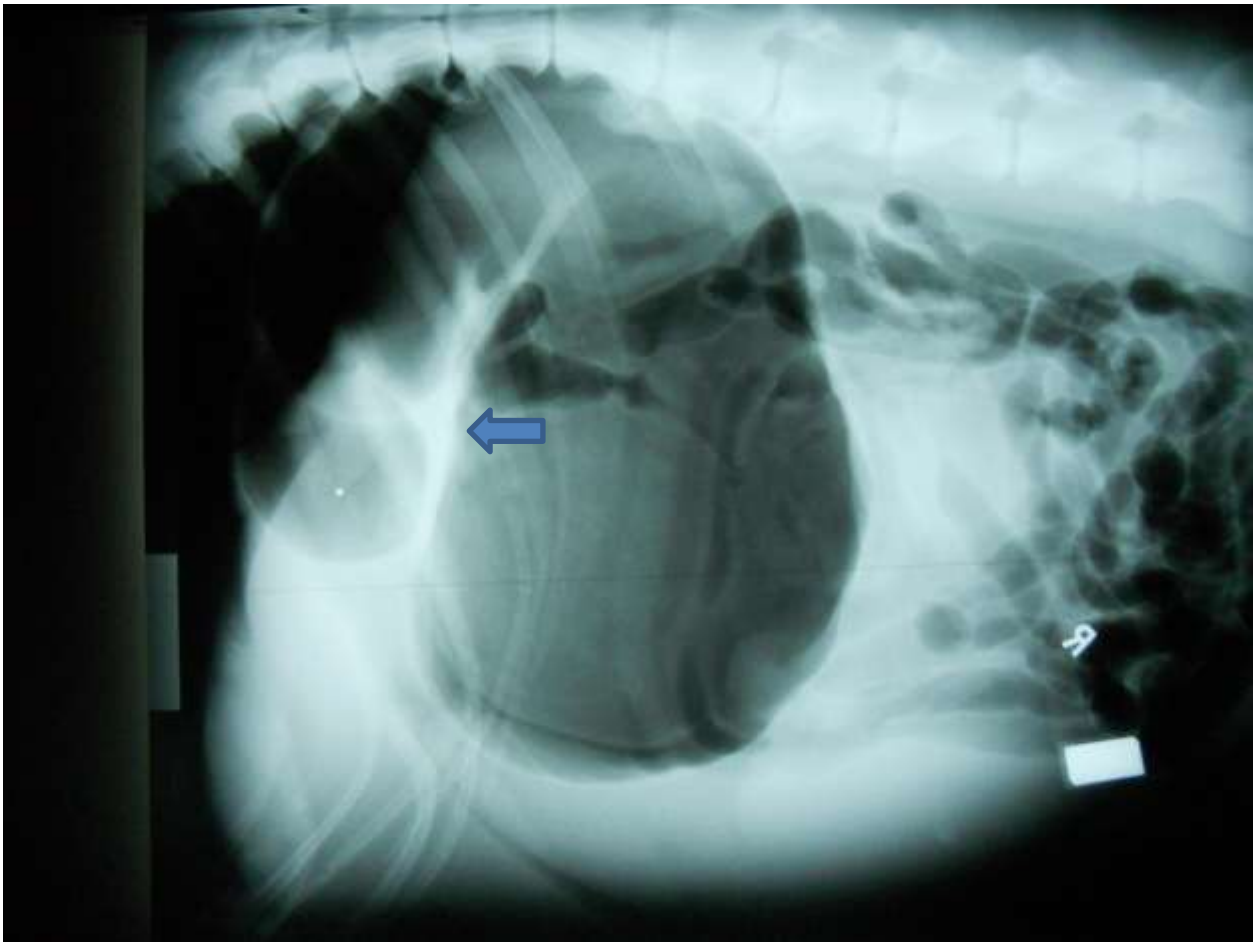

Figure 1 Right lateral abdominal radiograph of a 10-year-old, non-castrated male, Doberman dog with gastric dilatation-volvulus showing a distened, gas-filled stomach. Note a “shelf” of tissue (arrow), demonstrating that the stomach is malpositioned.

2.3.5 Laboratory findings

The complete blood cell count (CBC) is of little significance except when disseminated intravascular coagulation (DIC) causes thrombocytopenia. However, early hematologic characteristics probably reveal a stress leukogram in which leukocytosis with lymphopenia and monocytosis can be observed . Hemoconcentration can occasionally be found. Patients with GDV often have hypokalemia, hypernatremia, hypochloremia hyperphosphatemia, and increased serum phosphokinase and lactate concentrations. Hypokalemia possibly results from a decreased intake in association with increased loss of potassium in vomitus. Phosphorus is released from

degenerating cells and by the breakdown of adenosine triphosphate during hypoxia. Decreased glomerular filtration may also contribute to the rise in serum phosphorus (STROMBECK and GUILFORD, 1991). BEBCHUK et al. 2000 concluded that magnesium depletion is not pathophysiologically important in dogs with GDV and does not play a role in the cardiac arrhythmias detected in these patients. Biliary stasis, liver damage with a rise in serum alanine transaminase, and prerenal or renal azotemia can also be observed (MONNET, 2003). DE PAPP et al. (1999) reported that median plasma lactate concentrations in dogs with gastric necrosis (6.6 mmol/L) was significantly higher than in dogs without gastric necrosis (3.3 mmol/L). Therefore, preoperative plasma lactate concentration has been found to be a good predictor of gastric necrosis and of the prognosis for dogs with GDV.

2.4 Medical Treatment of GDV

The patient's stabilization should be performed immediately after a physical examination. It makes a patient a better candidate for surgical treatment. One or more large-bore intravenous catheters (16 guage) should be inserted in either a jugular or two cephalic veins of a dog affected with the GDV syndrome. Before a patient's stabilization with balanced electrolyte solution, blood samples should be withdrawn for an analysis of PCV and concentrations of serum total solids, blood glucose, BUN, plasma sodium, and plasma potassium, as well as for obtaining a CBC, blood gas, and serum biochemical analysis. Either isotonic fluid (90 ml/kg/h for the first hour), hypertonic 7% saline (4-5 ml/kg over 5-15 minutes), hetastarch (5-10 ml/kg over 10-15 minutes) or a mixture of 7.5% saline and hetastarch (dilute 23.4% saline with 6% hetastarch until you have a 7.5% solution; administer at 4 ml/kg over 5 minutes) should be infused to treat shock. Subsequent crystalloid fluid treatment should be adjusted thereafter. Periodic or continuous electrocardiographic monitoring should be performed in all dogs. Mesenteric congestion caused by the enlarged stomach predisposes the dog to infection and endotoxemia, making systemic antibiotic administration advisable. Broad spectrum antibiotics (e.g., cefazolin, ampicillin plus enrofloxacin) should be administered. Oxygen therapy may be administered by nasal insufflation or by a mask if the animal is dyspneic and or cyanotic. Decompression of the dilated stomach is then achieved by the passage of a stomach tube or by needle gastrocentesis. The stomach tube should be measured from the point of the nose to the xiphoid process and a piece of tape applied to the tube to mark the appropriate length. Placement of a dog in a sitting position may ease the

passage of the tube. Inability to pass a stomach tube is not diagnostic for volvulus, since a stomach tube can be passed in some dogs that have volvulus. Do not penetrate the esophagus with excessively rigorous attempts to pass the tube. If these attempts fail, percutaneous decompression of the stomach should be attempted. A sedative combination of oxymorphone (0.1 mg/kg, iv) and diazepam (0.5 mg/kg, iv) should be administered to noncompliant dogs. Sudden decompression is less desirable than a slower release of pressure, due to the fact that cardiovascular changes and reperfusion injury accompany decompression. Haemorrhagic fluid or the presence of black fragments of mucosa can be a sign of advanced stomach ischemia with likely necrosis of the mucosa of the body of the stomach. The stomach is then lavaged with warm water (5-10 ml/kg) injected from a gavage pump. The stomach should be drained again, and the lavage should be repeated two to three times. A right lateral abdominal radiographic view has been recommended for the best appearance of GDV. Additional radiographic views (ventrodorsal and left lateral views) should be taken if the first radiographic findings are equivocal. (BROCKMAN et al. 1995; MONNET, 2003; FOSSUM et al. 2002; NELSON and COUTO, 2003; STROMBECK and GUILFORD, 1991)

2.5 Surgical Treatment of GDV

The principal objectives of surgical treatment are 1) decompression and repositioning of the stomach, 2) resection of any pathologic gastric wall, and 3) prophylactic permanent gastropexy. Routine closure of every gastropexy can be performed with traditional suturing instruments. Alternatively, gastropexy with an automatic stapling instrument for the treatment of GDV was successfully performed by BELANDRIA et al. (2009). Pyloric surgery has frequently been suggested as a prophylactic procedure to accelerate the gastric emptying and decrease the likelihood of a recurrence of GDV. However, GREENFIELD et al. (1989) reported that radiographic evaluations of the width of the pylorus, the size of the stomach, and the rate of the gastric emptying showed no differences between dogs with and without Heineke-Mikulicz pyloroplasty at any evaluation period.

2.5.1 Methods of Gastropexy

2.5.1.1 Tube Gastropexy

Tube gastropexy (gastrostomy) is quick and relatively simple to perform. Additionally, postoperative gastric decompression and administration of medications directly into the stomach in inappetent animals can be quickly, easily, and effectively performed. The tube should be left

in place for at least 7 to 10 days to form a permanent adhesion (FOSSUM et al. 2002). Van Sluijs (1991) concluded that complications and recurrence rates after tube gastropexy (gastrostomy) did not differ significantly from a method of fixation of the pyloric antrum to the abdominal wall without a tube.

2.5.1.2 Circumcostal Gastropexy

Circumcostal gastropexy provides a stronger adhesion than most other techniques. The gastric position is only slightly altered. The risk of gastric leakage and abdominal contamination is diminished compared with tube gastropexy, because the gastric lumen is not entered. However, it does not provide direct access to the gastric lumen if postoperative decompression is necessary. This technique is more difficult to perform and takes greater surgical time. Pneumothorax and rib fracture can be possible complications (FOSSUM et al. 2002). EGGERTSDOTTIR et al. (2001) reported a 9 % recurrence rate of GDV after circumcostal gastropexy (median follow-up time: 700 days).

2.5.1.3 Muscular Flap (Incisional) Gastropexy

Muscular flap (incisional) gastropexy is simpler than circumcostal gastropexy. The risk of gastric leakage and abdominal contamination is diminished compared with tube gastropexy because the gastric lumen is not entered (FOSSUM et al. 2002). However, HAMMEL and NOVO (2006) reported a recurrence of GDV after incisional gastropexy in a Rottweiler. Their second abdominal exploratory surgery revealed a 180-clockwise GDV, with a stretched adhesion at the original gastropexy. If original gastropexy loosening is suspected, adhesion at this site can be effectively evaluated ultrasonographically. According the report of WACKER et al. (1998), ultrasonography proved to be a simple and non-invasive technique to assess the permanency of gastropexy. The most helpful sign in identifying the original gastropexy sites is simultaneous movement of the stomach and abdominal wall during respiration and peristaltic contractions of the stomach.

2.5.1.4 Belt-Loop Gastropexy

Belt-loop gastropexy is similar to a muscular flap (incisional) gastropexy except that a single flap is elevated and passed under a tunnel created in the abdominal wall. It is technically simple and provides adequate adhesions (FOSSUM et al. 2002).

2.5.1.5 Incorporating Gastropexy

Incorporating gastropexy is technically simple and can be learned and performed easily. This technique takes less surgical time, which diminishes the risk of anesthetic complications. Subsequent celiotomies such as ovariohysterectomy, enterotomy, or cystotomy can be performed safely without interference with the initial gastropexy area. However, dogs with this cranially located gastropexy may require a paracostal incision if it is later necessary to operate a diaphragmatic hernia or hepatic surgery. Therefore, it is recommended that owners of these dogs should inform the surgeons, if a subsequent celiotomy is necessary, that this method of gastropexy was previously performed (MEYER-LINDENBERG et al. 1993). The brief steps of incorporating gastropexy is shown in Figure 2.

Figure 2

Incorporating gastropexy. The stomach wall was grasped between thumb and index finger in the area of the pyloric antrum, was pulled into the cranial part of the celiotomy incision, and was fixed to the abdominal wall by incorporating the stomach into the main suture of the linea alba for approximately 5 cm. This suture line included the muscularis of the stomach, without entering the stomach lumen (MEYER -LINDENBERG et al. 1993).

2.5.1.6 Gastrocolopexy

Gastrocolopexy is one of the surgical techniques aimed at preventing a recurrence of GDV. In this technique, the greater curvature of the stomach is fixed to the transverse colon with suturing. It is technically simple to perform. The risk of gastric leakage and abdominal contamination is diminished compared with tube gastropexy because the gastric lumen is not entered. However, it does not provide direct access to the gastric lumen if postoperative decompression is necessary. EGGERTSDOTTIR et al. (2001) reported the recurrence rate of GDV after gastrocolopexy was 20 % (median follow-up time: 400 days). FLORIAN (2008) compared the gastrocolopexy technique and antropexy in the linea alba technique with regards to their ease of operation, efficacy and post-surgical clinical observations. This study showed that the gastrocolopexy technique had significantly poorer results when compared to alternative methods.

2.5.1.7 Laparoscopic Prophylactic Gastropexy

Laparoscopic prophylactic gastropexy is a procedure for the prevention of a first episode of GDV. It is performed with a minimal invasive technique. RAWLINGS et al. (2001) and RAWLINGS (2002) have reported that a laparoscopic-assisted gastropexy can be quickly, easily, and effectively performed in laboratory dogs. It can also be performed in GDV dogs as a surgical treatment.

2.5.1.8 Minilaparotomy Prophylactic Gastropexy

Minilaparotomy prophylactic gastropexy is an alternative technique for a prophylactic incisional gastropexy via a right-sided grid approach (minilaparotomy). STEELMAN-SZYMECZEK et al. (2003) performed a pilot study to compare this technique and a traditional ventral midline approach. This study showed comparable tensile strength between these two techniques.

2.6 Postoperative Care of GDV

The electrolyte, fluid, and acid-base status of a correctively operated dog should be monitored intensively, postoperatively. Many dogs with GDV are hypokalemic, particularly during the

postoperative period, and require potassium either intravenously or as an oral supplement. The hypokalemia probably results from a decreased intake in association with an increased loss of potassium in vomitus, by sequestration into the dilated stomach and resulting from metabolic alkalosis or hypovolemia induced hyperaldosteronemia (STROMBECK and GUILFORD, 1991; FOSSUM et al. 2002). Fluid therapy and analgesia should be continued for 48 hours, postoperatively. The electrocardiogram should be also monitored after surgery for 48-72 hours.

Periodic ventricular arrhythmia is common in dogs with GDV and normally begins 12-36 hours after surgery. Its etiology is unknown, but a myocardial depressant factor, reduced cardiac output, and myocardial ischemia may be contributing factors. Dogs should be treated with antiarrhythmic agents only if the arrhythmia is found to be related to poor tissue perfusion (as determined by arterial blood pressure, peripheral pulse quality, mucous membrane colour, capillary refill time), if preexisting cardiac disease is present (as determined from medical history), or when a persistent, closely associated multiform ventricular excitation or superimposition of the QRS wave on the T wave of the ECG trace (R on T phenomenon) is detected (BROCKMAN et al. 1995). In treating ventricular arrhythmias, lidocaine is to be administered 1-2 mg/kg intravenously as a bolus and then as a constant rate infusion at 60-100 μg/kg/min (MONNET, 2003). If necessary, anti-arrhythmics can be supplemented and continued with procainamide hydrochloride (12-20 mg/kg IM q 6 h, followed by 12-20 mg/kg PO q 6 h). Procainamide may also be administered, slowly, by IV (12-20 mg/kg over 15-20 minutes), followed by a constant rate infusion of 10-40 μg/kg/min (STROMBECK and GUILFORD, 1991). Ventricular arrhythmia in a rhythmic GDV dog could be effectively prevented by the use of metildigoxin and verapamil. Wieland (2002) compared a prophylactic combination therapy of ventricular arrhythmia between metildigoxin/verapamil and metildigoxin/mexiletin. There was statistically significant difference between the two prophylactic combination groups concerning of the suppression of ventricular arrhythmias. Signs of lidocaine toxicity include muscle tremors, vomiting, and seizures; and lidocaine therapy should be discontinued if these signs occur. Lidocaine toxicity may be enhanced in patients given cimetidine concurrently (FOSSUM et al. 2002). Postoperative cardiac troponin I and cardiac troponin T concentrations in GDV dogs have been found to be associated with severity of the EKG abnormalities and outcomes (SCHOBER, et al. 2002) Therefore, cardiac troponin I and cardiac troponin T can be alternatively used as prognostic indicators, postoperatively.

Administration of H_2-blockers such as ranitidine (1-2 mg/kg q 8-12 hr IV, IM, PO) and cimetidine (4-5 mg/kg q b hr IV, IM, PO) may ameliorate gastric ulceration. Sucralfate (0.5-1 gm q 8 hr PO) may facilitate the healing of gastric ulcers. If vomiting is severe or continuous, a centrally acting antiemetic may be given (metoclopramide 0.25-0.5 mg/kg PO, IV, or SC SID-QID). It also helps to increase the contraction at the pyloric antral area and coordinates pyloric and duodenal motility, thereby facilitating gastric emptying (ELLISON, 1993).

Prolonged ischemia results in tissue necrosis which is irreversible and cannot be treated medically. However, temporary ischemia followed by reperfusion with oxygenated blood may cause a type of tissue damage referred to as reperfusion injury. Severity of reperfusion injury in a dog with GDV may be reduced by appropriate and timely pharmacologic intervention. The use of an antioxidant and iron chelator to prevent the effects of reperfusion injury is questionable during the treatment of GDV. Deferoxamine and allopurinol have been shown to improve survival in a research experiment. BADYLAK et al. (1990) reported that tissue malondialdehyde concentration, a nonspecific indicator of lipid peroxidation, was significantly ($P<0.05$) greater in the duodenum, jejunum, colon, liver, and pancreas of the saline solution-treated and allopurinol-treated dogs than in the same tissues of U74006F-treated dogs after surgical correction of experimentally induced GDV, compared with malondialdehyde concentrations determined before inducing GDV. LANTZ et al. (1992) have found that deferoxamine may be more effective than dimethylsulfoxide in ameliorating the effects of reperfusion injury.

3. Materials and Methods: A 6-year Retrospective Study of Canine Gastric Dilatation-Volvulus Treated with Incorporating Gastropexy

3.1 Subjects

Animals presented with GDV syndrome at the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009 were diagnosed and treated with standard protocol . The symptoms of acute GDV were distended or bloated abdomen, nonproductive retching, regurgitation of mucus and hypersalivation. Other common symptoms included depression, abdominal pain, lethargy, weakness, salivation, tachypnea and restlessness due to abdominal pain (especially in the early stages). A retrospective review of medical records and patient databases of these dogs was completed. A diagnosis of GDV was supported by a right lateral abdominal radiographic view. On the right lateral view of a dog with GDV, the pylorus lay cranial to the body of the stomach and was separated from the rest of the stomach by soft tissue (reverse C-sign). Volvulus was denoted by displacement of the pylorus and/or formation of a "shelf" of tissue in a gastric shadow (Figure 1).

3.2 Study design and method of data collection

This study is a retrospective observational study. Data gained from the medical record comprised age, breed, sex, weight, medical history, duration of clinical signs until presentation to the hospital, physical examination findings, results of laboratory tests and diagnostic radiographies, surgical findings, peri-operative complications, mortality rate, occurrence of cardiac arrythymias, length of hospital stay, prevalence and type of postoperative complications, and overall outcome (survive and death or euthanasia).

3.3 Standard procedures

3.3.1 Standard medical treatment

3.3.1.1 Patient stabilization

A physical examination was immediately performed which included vital signs, and abdominal palpation and percussion. In the case of GDV, clinical signs related to shock syndrome may be obviously present, including weak peripheral pulses, tachycardia, prolonged capillary refill time, pale mucous membrane, or dyspnea. One or more large-bore intravenous catheters (16 guage) (Figure 3) were placed in the cephalic or jugular veins of dogs affected with the GDV syndrome. Intravenous catheters should not be placed in the lateral saphenous veins if the stomach has not been adequately decompressed to allow fluid administered at the site to return unhindered to the heart. Venous cutdown procedures may be required in patients with collapsed veins as a result of severe hypotension and poor peripheral circulation (DIBARTOLA et al., 2006).

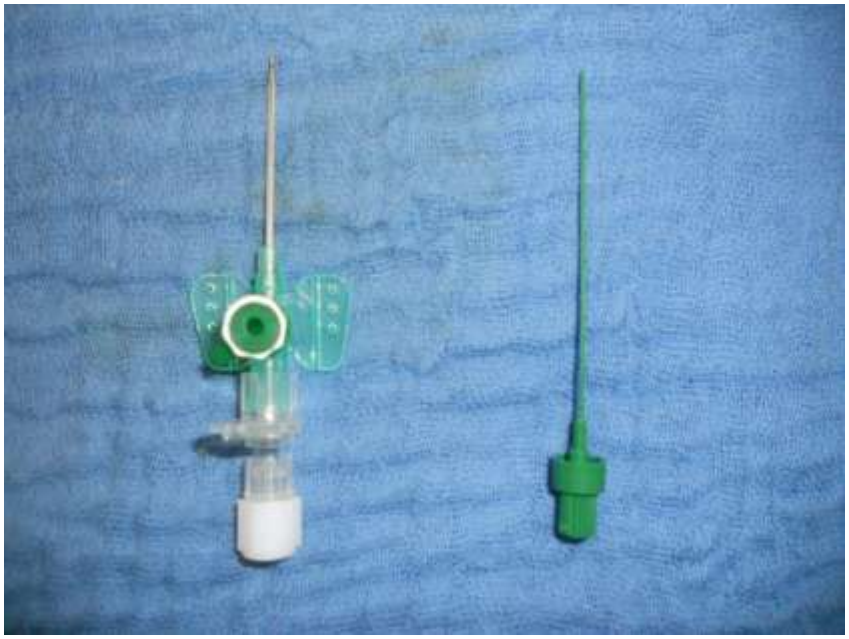

Figure 3 Intraveonos catheter 16 gauge

3.3.1.2 Blood collection

Blood samples were collected immediately during intravenous catheter placement for analysis of conplete blood count (CBC), total protein and blood chemistry. Additional bood investigations included a coagulation profile (PT, PTT), a white blood cell differential count, and blood gas analysis, performed based on clinician discretion at the time the case was managed. Preoperative plasma lactate concentration in a heparinized blood sample obtained prior to administration of intravenous fluids was found to be a good predictor of gastric necrosis and of the outcome for dog with GDV. DE PAPP et al. (1999) reported that median plasma lactate concentration in dog with gastric necrosis (6.6 mmol/L) was of significantly higher concentration in dogs without gastric necrosis (3.3 mmol/L).

3.3.1.3 Fluid therapy

Balanced electrolyte crystalloid solution (Lactated Ringer Solution; Sterofundin®) was immediately infused at a rate of 90 mL/kg of body weight/ h for the first hour and in some cases, combined with colloidal solution (Venofundin®) at a rate of 5-10 mL/ kg of body weight over 10-15 minutes for more effective shock treatment (Figure 4). Subsequent crystalloid fluid treatment was adjusted thereafter based on a patient's condition evaluated by vital signs and central venous pressure. It is recommended that any acid-base and electrolyte (potassium, calcium) abnormalities was adjusted based on initial laboratory result. After the first one to two hours, re-evaluate the patient's cardiovacular condition. Normally decrease the rate to 20-40 ml/kg/h until the patient is satbilized. Continue at 10-20 ml/kg/h to maintain perfusion.

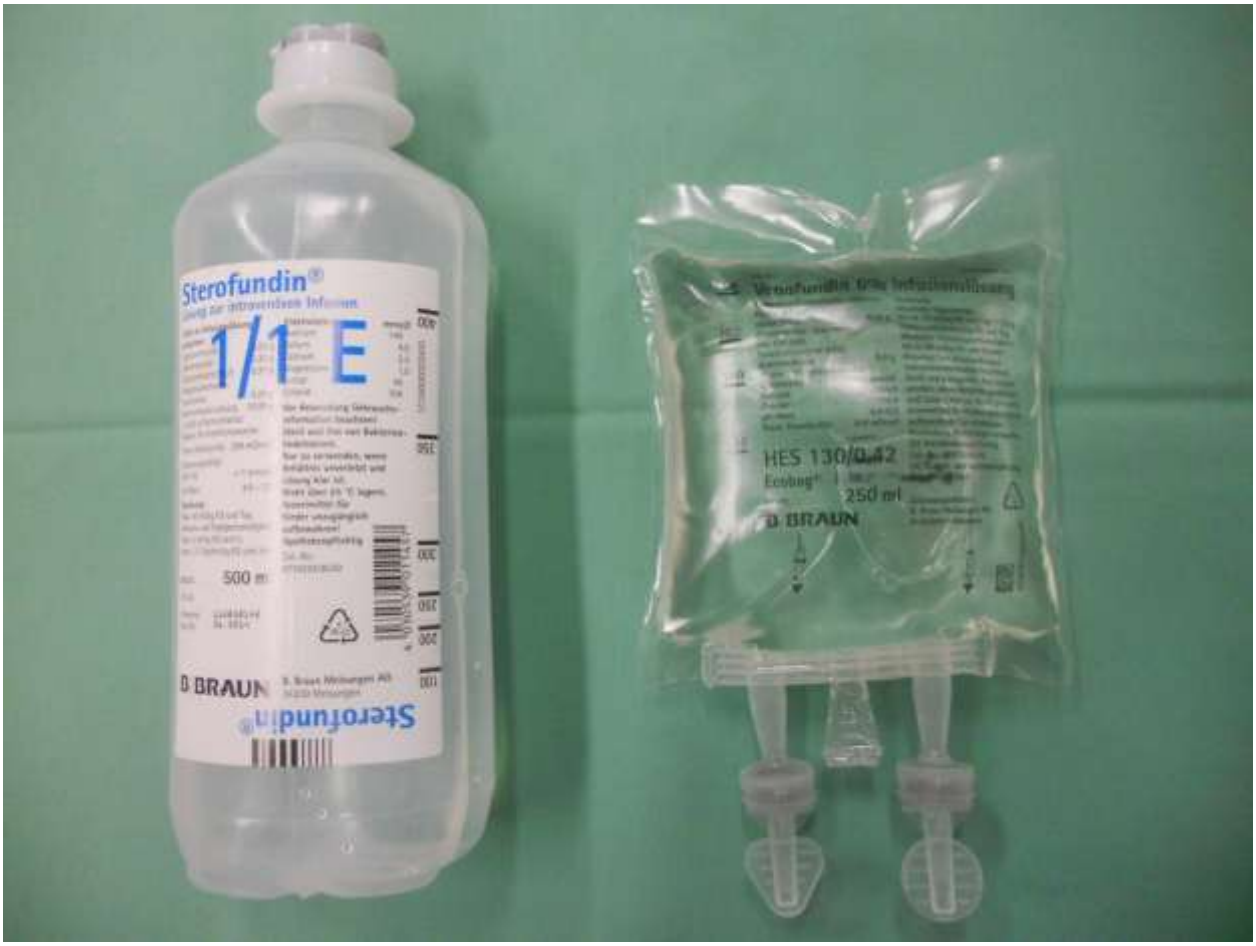

Figure 4 Crystalloid and colloid infusions

3.3.1.4 EKG

Continuous electrocardiography (ECG) monitoring (Figure 5) was performed in all GDV dogs during operation. The heart rate and rhythm were intensively monitored. Some dogs with GDV developed cardiac arrhythmias. Cardiac arrhythmia is a common cause of death in dogs with GDV. Dogs that already have a cardiac disease or are prone to heart arrhythmias are generally treated with appropriate medications. Different arrhythmias may be observed, but the most common arrythymias are premature ventricular contractions (PVCs) (Figure 6).

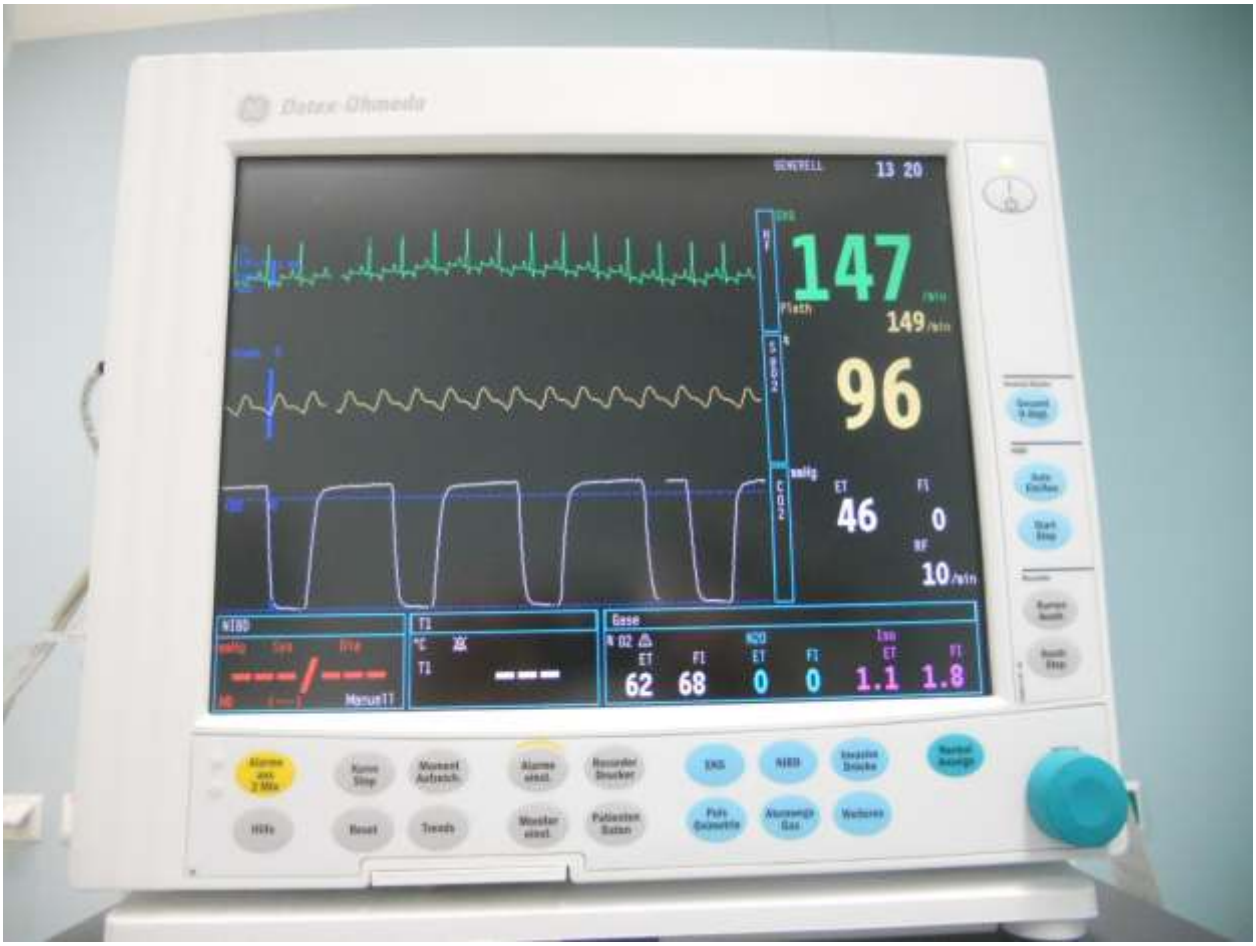

Figure 5 Perioperative continuous electrocardiography and vital signs monitoring

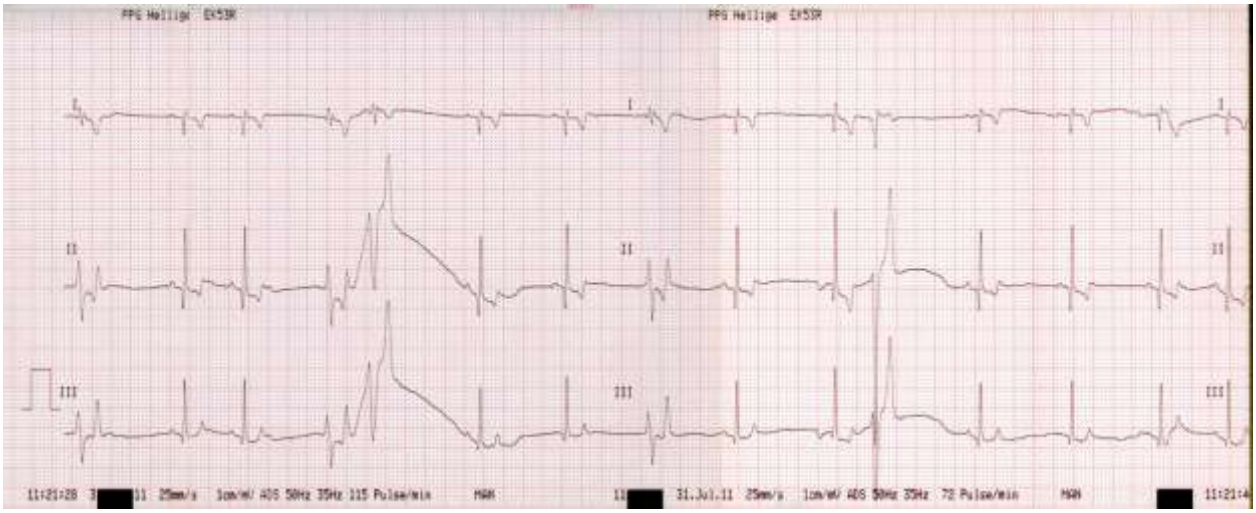

Figure 6 EKG of a 5-year-old, non-neutralized female, Rottweiler dog with gastric dilatation-volvulus showing a premature ventricular contractions (PVCs)

3.3.1.5 Antibiotics

Antibiotics should be given to GDV dogs because mucosal damage, shock, and portal hypertension predispose them to sepsis. Antibiotics should be effective against gram-positive, gram- negative, and anaerobic organism (Tams, 2003). Intravenous prophylctic antibiotic (Amoxicillin-clavulanic acid 25mg/kg) was administered to prevent gastrointestinal infection that can lead to endotoxemia (bacterial poisoning of the body which causes illness and shock)

3.3.1.6 Corticosteroids

Corticosteriods have been shown to be beneficial in hypovolemic shock by stabilizing lysosomal membranes, increasing cardiac output, and helping to maintain integrity of the circulatory system. For endotoxic shock, steroids reduce serum levels of endotoxin, promote clearance by the reticuloendothelial system, and interfere with induced immune reactions by decreasing complement fixation. Methyl prednisolone (Medrate©) 15-30 mg/kg was sometimes administered to the GDV dog intravenously.

3.3.1.7 Oxygen therapy

Oxygen therapy is sometimes required for dogs with dyspneoa or cyanotic mucous membrane (hypoxia)

3.3.1.8 Decompression

Gastric decompression was successfully performed by a percutaneous needle gastrocentesis, an orogastric intubation, or a combination of these two methods. It helped to improve venous return, ventilation, and perfusion of the stomach wall. Gastric decompression should be performed as soon as intravenous catheters have been placed. The decompressed-GDV dog will then be a safe candidate to be radiographed.

3.3.1.8.1 Orogastric tube

A flexible but stiff polyvinyl orogastric tube, with a tapered proximal end, was measured and marked from the tip of the nose to the xiphoid.The tube was lubricated with gel before placement into the stomach. We found that holding the mouth closed over a mouth gag helped prevent orogastric tube chewing in lightly sedated patients. The tube was then introduced to the stomach slowly until the marked point was at the nose tip to minimize the iatrogenic gastric trauma. It is worth noting that once the stomach tube is inserted, you will generally meet resistance at the esophageal-stomach junction. Pass the tube firmly in a twisting manner to pass the lower esophageal sphincter. If orogastric tubing fails, place the patient in different positions and try again to pass the tube (i.e., elevate animal at 45 degree angle with rear feet on floor and forefeet on table, right lateral recumbancy, and left lateral recumbancy). This movement may help the stomach to rotate enough to allow tube passage. Be careful not to position the patient in dorsal recumbancy as this will increase abdominal visceral pressure on the caudal vena cava. If it is still unsuccessful, try different diameter tubes; start with a smaller diameter, more flexible tube and continue as described above.

3.3.1.8.2 Percutaneous

If orogastric tubing is not achieved, then perform percutaneous decompression. An area caudal to the right 13^{th} rib should be clipped and scrubbed aseptically. Ping the area to be certain that the spleen is not under the proposed trocarization site. Trocarize the stomach with one or two 18- or 20- GA needles. After percutaneous decompression, try again to pass the stomach tube as described above.

3.3.2 Standard radiography

A right lateral abdominal radiographic view was performed after fluid therapy and temporary gastric decompression had been initiated. If the gas filled pylorus was found to be located dorsally relative to the gastric fundus, a radiographic diagnosis of GDV was made. It is possible that compartmentalization of the gas filled stomach can be seen and has been described as 'double bubble phenomenon'. On the right lateral view of a dog with GDV, the pylorus lies cranial to the body of the stomach and is separated from the rest of the stomach by soft tissue (reverse C-sign). Volvulus is denoted by displacement of the pylorus and/or formation of a "shelf" of tissue in a gastric shadow (Figure 1).

3.3.3 Standard anesthesia

GDV dogs were sedated with midazolam (0.1-0.3 mg/kg) and levomethadone hydrochloride (0.1 mg/kg) intravenously. Induction of anesthesia was achieved by intravenous propofol (4-6 mg/kg). Anesthesia was then maintained with isoflurane in 100 % oxygen. Intravenous fluid administration was continued at a rate of at least 20 ml/kg/h. Type, composition and rate of fluid given to a GDV patient were adjusted according to alterations in heart rate, peripheral pulse, mucous membrane colour, PCV, and serum total protein, BUN, blood glucose, plasma sodium and plasma potassium. Warm intravenous fluid administration and use of a warm air ventrilator machine (Bair Hugger)® helped prevent hypothermia peri- and post-operatively (Figure 7). Continuous electrocardiography (ECG) and pulse oxymeter monitoring were performed in all GDV dogs during operation.

Figure 7 A warm air ventrilator machine (Bair Hugger)®

3.3.4 Emergency corrective surgery

Once the dog is stabilized, it is a good candicate for abdominal surgery. The surgery's objective is to achieve three things—assessment of the stomach and surrounding organs, stomach repositioning, and gastropexy.

3.3.4.1 Assessment of stomach and surrounding organs

The health and vitality of the stomach and surrounding organs were assessed. The colour of the stomach wall can predict the health status and viability of the stomach. After derotation and decompression the gastric wall may change its colour to a more normal pink or hyperemic red in 10-15 minutes or it may not totally change its colour. The grey color of a stomach wall reflects arterial stasis which can lead to the necrosis. Black color of the stomach wall means that it has already necrotized, in such a case, partial gastrectomy needs to be performed. The chances for recovery are very poor, and euthanasia may be an alternative. The blue colour of the stomach wall reflects venous stasis. If small incisions into the muscular layer of the stomach do not bleed, then resection should definitively be performed. Observation of a potential seriously bleeding vessel is necessary. Splenic vessels should be observed for vascular tears. Vessel ligation is performed immediately if a vessel tear is evident. In case of splenic injury or rupture, a partial or total splenectomy might be necessary. Figure 8 shows extensive necrotic area of the twisted stomach in a GDV dog which was euthanized.

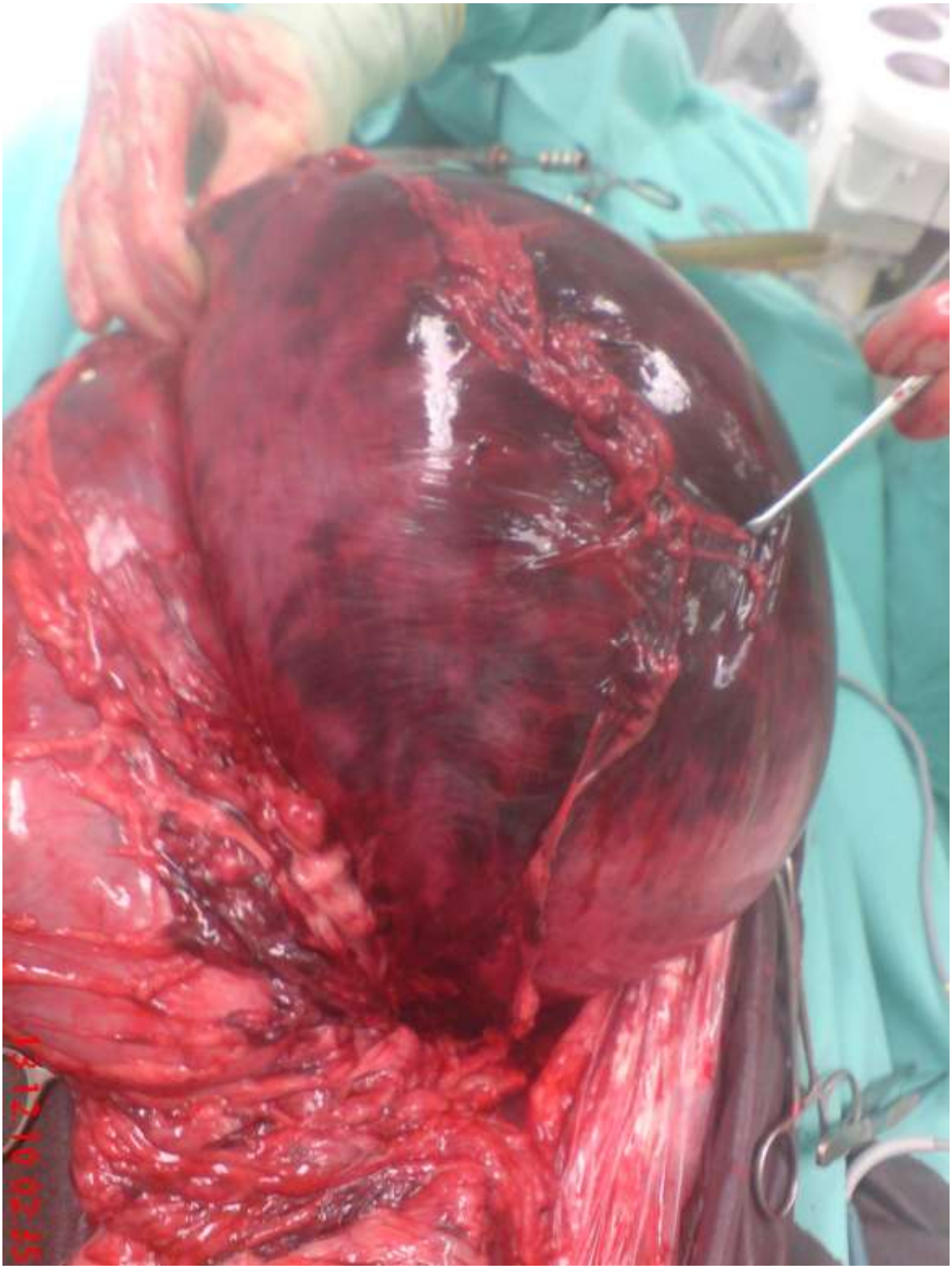

Figure 8　Extensive necrotic area of the twisted stomach in a GDV dog

3.3.4.2 Repositioning of stomach

Anatomic derotation of the stomach is necessary to prevent recurrence of GDV. Repositioning will sometimes happen spontaneously at the time of decompression. Do not attemp to derotate a dilated stomach. The risk of vascular tear, especially from the spleen is quite high. Knowledge of normal anatomy is necessary to understand how derotation of the stomach is to be performed. In each case the same procedure is performed to derotate the stomach. The pylorus, located near the cardia of the stomach, is grasped with the right hand and elevated from the left ventral side towards the midline and right side as the left hand presses down on the fundus of the stomach towards the surgical table. Repositioning of the stomach is easily performed if the stomach has been decompressed.

3.3.4.3 Incorporation gastropexy technique

The incorporation gastropexy technique has been found to be technically simple and can be learned and performed easily. The gastropexy is made by gripping the pyloric antrum with a wet gauze, fingers or Allis tissue forceps and elevating the stomach wall into the cranial aspect of the linea alba incision. Only the serosal and muscular layer of the stomach wall are grasped and sutured to the cranial part of the celiotomy incision with delayed-absorbable or non-absorbable suture materials. The rest is fixed to the abdominal wall by incorporating the stomach into the main suture of the linea alba for approximately 5 cm. Care must be taken not to enter the stomach lumen. Attempting to place the stomach in the normal position is possible when the animal resumes a normal upright body posture. The remaining abdominal wall layers can then be closed in a routine manner (figure 2) (MEYER-LINDENBERG et al. 1993).

3.3.5 Post-opearive care

After surgery, the dog should be intensively monitored for several days for signs of infection, cardiac arrythymias, DIC, stomach ulceration or perforation, and damage to the pancreas or liver. Antibiotics and additional medications may need to be administered. The dog may need to be hospitalized for several days on intravenous fluids and pain medications as well as for treatment of any symptoms or secondary problems that might arise. The dog should be held off food and

water for 24 hours following surgery. After 24 hours without vomiting, oral administration was started gradually with a sequence of ice cubes, water, a bland diet and finally soft canned dog food. This should occur over a 2-3 day period. Monitor serum potassium levels and supplement fluids with potassium chloride as needed. In our clinic, central venous catheter placement is regularly performed in every patient to provide the measurement of central venous pressure. Amoxicillin- Clavulanic acid 12.5 mg/kg is administered twice a day. Analgesics used in our clinic are Metamizole (20-50 mg/kg bid intravenous) and Buprenorphine (0.03 mg/kg tid subcutaneous). Additionally the dog is administered Metoclopramide (0.3 mg/kg bid subcutaneous) and Ranitidine (1mg/kg bid intravenous). EKG is regularly performed at least three times a day post-operatively.

Ventricular extrasystoles (VES) are common in dogs with GDV and normally begin 12-36 hours after surgery. Their etiology is unknown but myocardial depressant factors, reduced cardiac output, endotoxin, electrolyte disturbances (hypokalemia and hypomagnesemia) and myocardial ischemia may contribute. VES should be intensively treated if: there are more than 20-30 VES/minute; tachycardia (heart rate > 160 bpm) presents; paroxysmal ventricular tachycardia occurs; R on T phenomenon is observed; and there is evidence of impaired cardiac output or lack of palpable femoral pulse during tachycardia. In our clinic, treating ventricular arrhythmias, lidocaine is administered 2 mg/kg intravenously as a bolus and then as a constant rate infusion at 50 μg/kg/min. If necessary, antiarrhythmic can be supplemented and continue with procainamide hydrochloride (10 mg/kg IM q 6 h). Blood pressure should be routinely controlled. DIC is a common complication of GDV and is revealed initially by the presence of thrombocytopenia and prolonged coagulation time. If DIC is diagnosed, treatment with fresh frozen plasma should be initiated. Figure 9

Figure 9 Plasma transfusion

3.4 Statistical analysis

Statistical analyses were performed by use of the software PASW Statistics version 18. To test the association between 2 categoric variables, the χ^2 test was used. An independent samples t-test was conducted to compare mean (continuous data) between survivor and non-survivor group. All tests used were 2-tailed, and $P \leq 0.05$ was considered significant.

4. Results

4.1 Signalments

Of the total number of 26,914 dogs treated at the Clinic for Small Domestic Animals, Free University of Berlin, Germany, between 2004 and 2009, 181 dogs (0.67 %) presented with GDV syndrome have been taken into account (Table 1).

Results show that the number of dogs that presented with GDV syndrome ranged from 16 cases in 2009 to 44 cases in 2004. Of them 43.33 % (n=78) were intact males, 20.00 % (n=36) neutered males, 22.22 % (n=40) intact females and 14.44% (n=26) neutered females, yielding a male:female ratio of 1.72:1 (Table 2, figure 10). One dog had no information about sex. The figure 11 shows the age distribution at the time of presentation. Only six patients (3.4 %) presented at our hospital were below the age of two years. Age groups were significantly (χ^2 = 21.82, df = 7, $p = 0.003$) associated with outcome of overall morbidity (Table 3). The median age at the time of onset of symptoms was 8.46 (range: 0.26-15.9) years. The mean age at time of presentation was 8.42 years (range: 0.3-15.9). The mean body weight at the time of presentation was 40.43 kg (range:12-80 kg). The median body weight at the time of presentation was 38.0 kg (range: 12-80 kg) years (Table 4). All the dogs were divided into three groups according to their weights (Table 5 and figure 12). Incorporating gastropexies were performed to correct GDV in 125 (69.1 %) dogs.

Table 1 Dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

Year	Total number of dogs	Total number of dogs presenting with GDV syndrome	Per cent of dogs presenting with GDV syndrome in the total number of dogs per year
2004	4,360	44	1.01 %
2005	4,439	36	0.81 %
2006	4,202	32	0.76 %
2007	4,737	24	0.51 %
2008	4,459	29	0.65 %
2009	4,717	16	0.34 %
Total	26,914	181	0.67 %

Table 2 Sex distribution among GDV-involved symptom patients at Free University of Berlin, 2004-2009

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**intact male**	78	43.09	43.33	43.33
	neuterd male	36	19.89	20.00	63.33
	intact female	40	22.10	22.22	85.56
	neuterd female	26	14.36	14.44	100.00
	Total	180	99.45	100.00	
Missing	**System**	1	0.55		
Total		**181**	**100.00**		

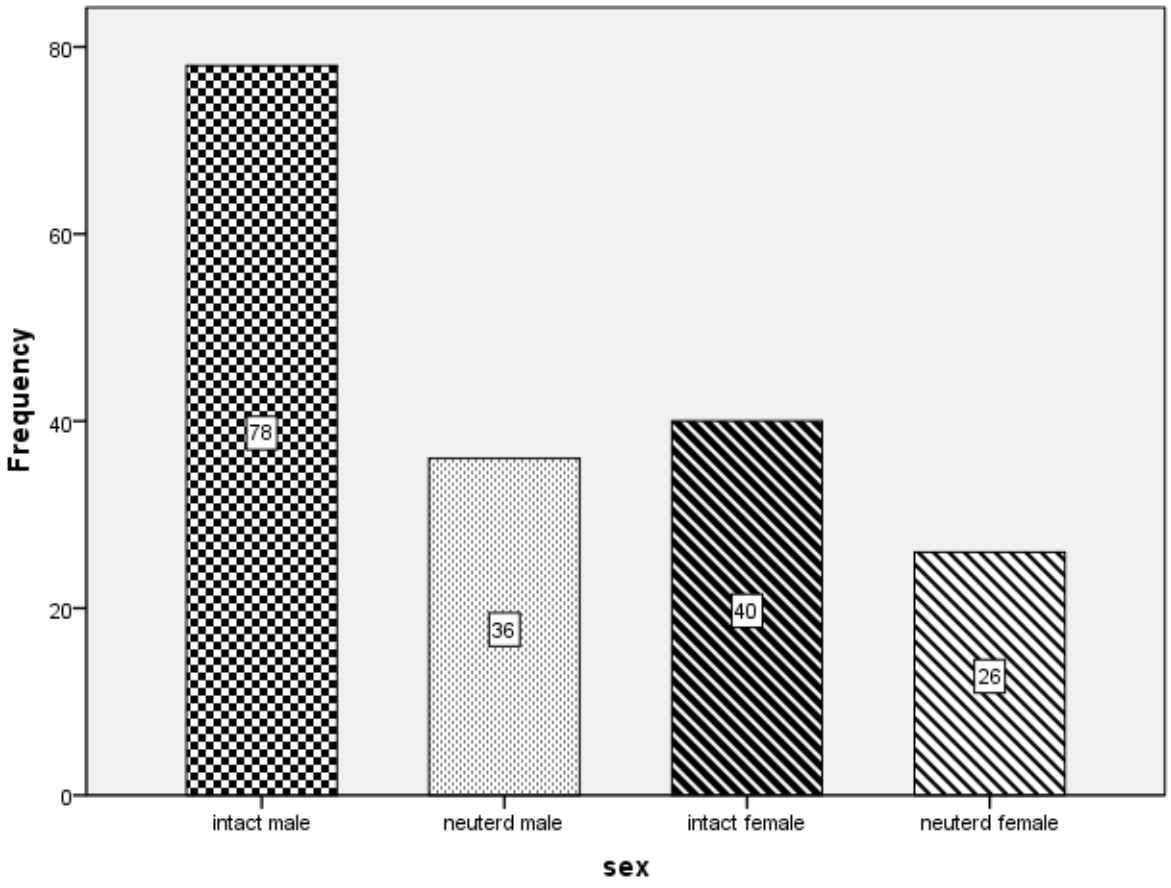

Figure 10 Sex distribution among GDV-involved symptom patients at Free University of Berlin, 2004-2009

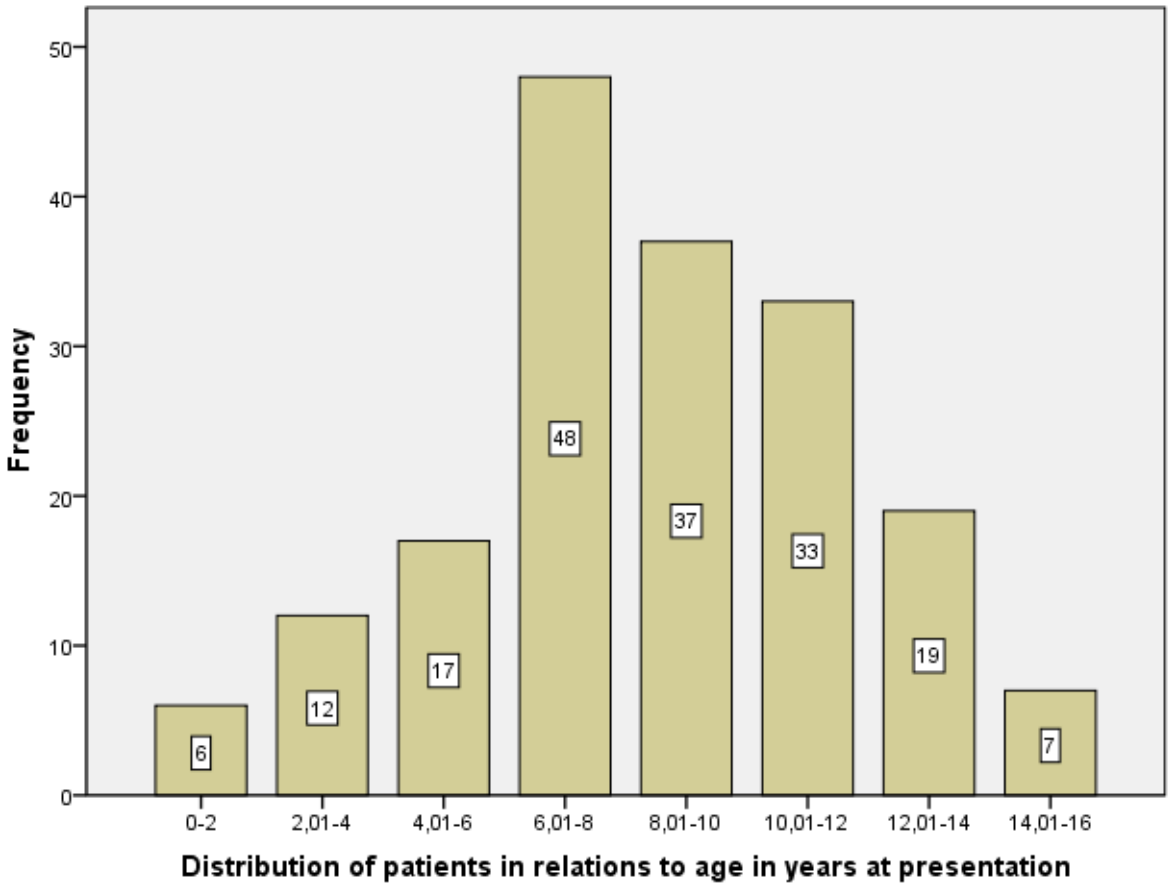

Figure 11 Age distribution at the time of presentation at Free University of Berlin, 2004-2009

Table 3 Age groups and outcome (discharge vs death or euthanasia) of overall morbidity

			Outcome (discharge vs death or euthanasia)		
			Discharge	**Death**	**Total**
Age groups (years)	**0-2**	Count	6	0	6
		Exp. Count	4.66	1.34	6
		% of Total	3.35	.00	3.35
	2,01-4	Count	11	1	12
		Exp. Count	9.32	2.68	12
		% of Total	6.15	.56	6.70
	4,01-6	Count	14	3	17
		Exp. Count	13.20	3.80	17
		% of Total	7.82	1.68	9.50
	6,01-8	Count	36	12	48
		Exp. Count	37.27	10.73	48
		% of Total	20.11	6.70	26.82
	8,01-10	Count	31	6	37
		Exp. Count	28.73	8.27	37
		% of Total	17.32	3.35	20.67
	10,01-12	Count	29	4	33
		Exp. Count	25.63	7.37	33
		% of Total	16.20	2.23	18.44
	12,01-14	Count	8	11	19
		Exp. Count	14.75	4.25	19
		% of Total	4.47	6.15	10.61
	14,01-16	Count	4	3	7
		Exp. Count	5.44	1.56	7
		% of Total	2.23	1.68	3.91
Total		Count	139	40	179
		Exp. Count	139.00	40.00	179
		% of Total	77.65	22.35	100

Exp. Count= Expected count

Table 4 Descriptive statistics of age and body weight

		Age in years	body weight in kilograms
N	Valid	179	144
	Missing	2	37
Mean		8.42	40.43
Std. Error of Mean		.24	1.07
Median		8.46	38.00
Std. Deviation		3.27	12.80
Variance		10.72	163.76
Range		15.64	68.00
Minimum		0.26	12.00
Maximum		15.90	80.00

Table 5 Weight groups and sex distribution of 181 dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

			sex				
			intact male	neuterd male	intact female	neuterd female	Total
Body weight groups (kg)	< 15 kg	Count	1	0	0	0	1
		Expected Count	.45	.19	.22	.15	1.00
		% of Total	.69	.00	.00	.00	.69
	15,1-30 kg	Count	7	3	11	5	26
		Expected Count	11.74	4.88	5.60	3.79	26.00
		% of Total	4.86	2.08	7.64	3.47	18.06
	30,1 kg up	Count	57	24	20	16	117
		Expected Count	52.81	21.94	25.19	17.06	117.00
		% of Total	39.58	16.67	13.89	11.11	81.25
Total		Count	65	27	31	21	144
		Expected Count	65.00	27.00	31.00	21.00	144
		% of Total	45.14	18.75	21.53	14.58	100

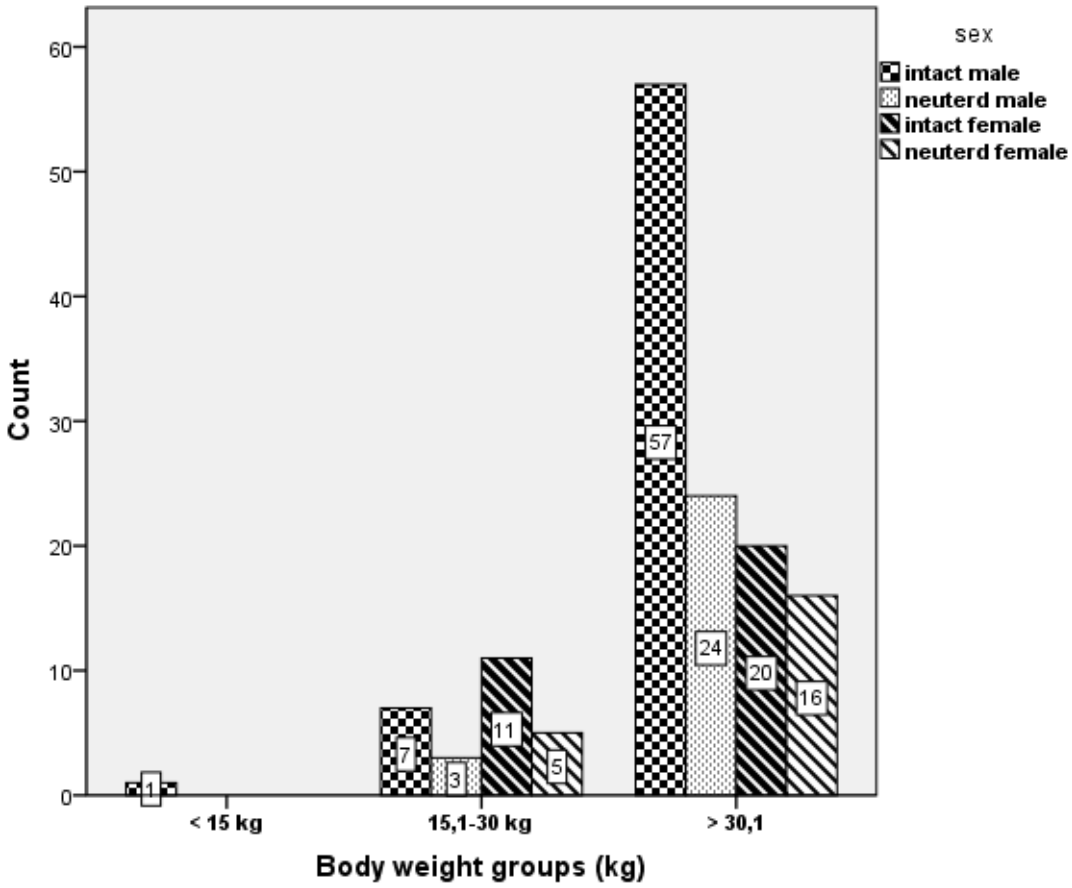

Figure 12 Weight groups and sex distribution of 181 dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

Fourty-three breeds were represented, including 26 (15.00 %) German Shepherd, 18 (10.4 %) of each the Great Dane and large mixed breed, 13 (7.5 %) Dobermans, 11 (6.4 %) Bernese mountain dogs, 8 (4.6 %) Rhodesian Ridgebacks, 7 (4.0 %) of each of medium mixed breed, the Boxers and the Giant Schnauzers, 5 (2.9 %) Hovawarts, 4 (2.3 %) of each of the Briards and the Landseers, 3 (1.7 %) of each of the Bordeaux Mastiffs, the German Wirehaired Pointers and the Irish Red and White Setters, 2 (1.2 %) of each of the Anatolian Shepherd, the Chow Chows, the Dalmatians, the Kuvaszes, the Leonbergers, the Newfoundlands and the Rottweiler. The other breeds had only one (0.6 %) case each. The percentage of incidence of GDV-involved symptomatic patients, by individual breeds, is shown in the Table 6. All the dogs were divided into three breed groups according to their sizes. The small breeds consisted of the Dachshund and the Beagle. The medium breeds consisted of medium mixed-breed, the Siberian Husky, the American Staffordshire Terrier, the German Longhaired Pointer, the German Shorthaired Pointer, the GermanWirehaired Pointer, the Dalmatian, the Samoyed Dog, the Sharpei, the Eurasier, the English Bulldog, the Pointer, the Standard poodle, the Koenigspudel, the Hovawart,the Irish Setter, the Chow Chow, the Pudelpointer, the Weinmaraner, and the Malinois. The large breed consists of German Shepherd Dog, doberman, boxer, rottweiler, bernese mountain dog, great dane, briard, Giant schnauzer, Bordeaux Mastiff, Gordon Setter, Greenland Dog, Spinone Italiano, Kuvasz, Irish wolfhound, landseer, Rhodesian ridgeback, Newfoundland, American sherpherd dog, Anatolian Shepherd Dog, Leonberger and Greater Swiss Mountain Dog. Breed groups and sex distribution are shown in Table 7 and figure 13.

Table 6 Incidence of GDV-involved symptom patients in pure breed dogs and mongrels

Breed	Number	Percent
German Shepherd Dog	26	14.4
Large mixed breed	18	9.9
Great Dane	18	9.9
Doberman	13	7.2
Bernese Mountain Dog	11	6.1
Rhodesian Ridgeback	8	4.4
Missing data	8	4.4
Medium mixed breed	7	3.9
Boxer	7	3.9
Giant schnauzer	7	3.9
Hovawart	5	2.8
Briard	4	2.2
Landseer	4	2.2
Bordeaux Mastiff	3	1.7
German wirehaired pointer	3	1.7
Irish Red and White Setter	3	1.7
Anatolian Shepherd Dog	2	1.1
Chow chow	2	1.1
Dalmatian	2	1.1
Kuvasz	2	1.1
Leonberger	2	1.1
Newfoundland	2	1.1
Rottweiler	2	1.1
American Shepherd Dog	1	0.6
American Staffordshire Terrier	1	0.6
Beagle	1	0.6
Belgian Shepherd Dog (Malinois)	1	0.6
Dachshund	1	0.6
English bulldog	1	0.6
Eurasier or Eurasian	1	0.6
German longhaired pointer	1	0.6
German shorthaired pointer	1	0.6
Gordon Setter	1	0.6
Greater Swiss Mountain Dog	1	0.6
Greenland Dog	1	0.6
Irish wolfhound	1	0.6
Koenigspudel	1	0.6
Pointer	1	0.6
Pudelpointer	1	0.6
Samoyed dog	1	0.6
Shar Pei	1	0.6
Siberian Husky	1	0.6
Spinone Italiano	1	0.6
Standard Poodle	1	0.6
Weimaraner	1	0.6
Total	**181**	**100**

Table 7 Breed group and sex distribution of 181 dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

			sex				
			intact male	neuterd male	intact female	neuterd female	Total
breed groups	small breed	Count	2	0	0	0	2
		Expected Count	.87	.39	.45	.29	2.00
		% of Total	1.12	.00	.00	.00	1.12
	medium breed	Count	18	5	7	6	36
		Expected Count	15.69	7.04	8.04	5.23	36.00
		% of Total	10.06	2.79	3.91	3.35	20.11
	large breed	Count	58	30	33	20	141
		Expected Count	61.44	27.57	31.51	20.48	141.00
		% of Total	32.40	16.76	18.44	11.17	78.77
Total		Count	78	35	40	26	179
		Expected Count	78.00	35.00	40.00	26.00	179.00
		% of Total	43.58	19.55	22.35	14.53	100.00

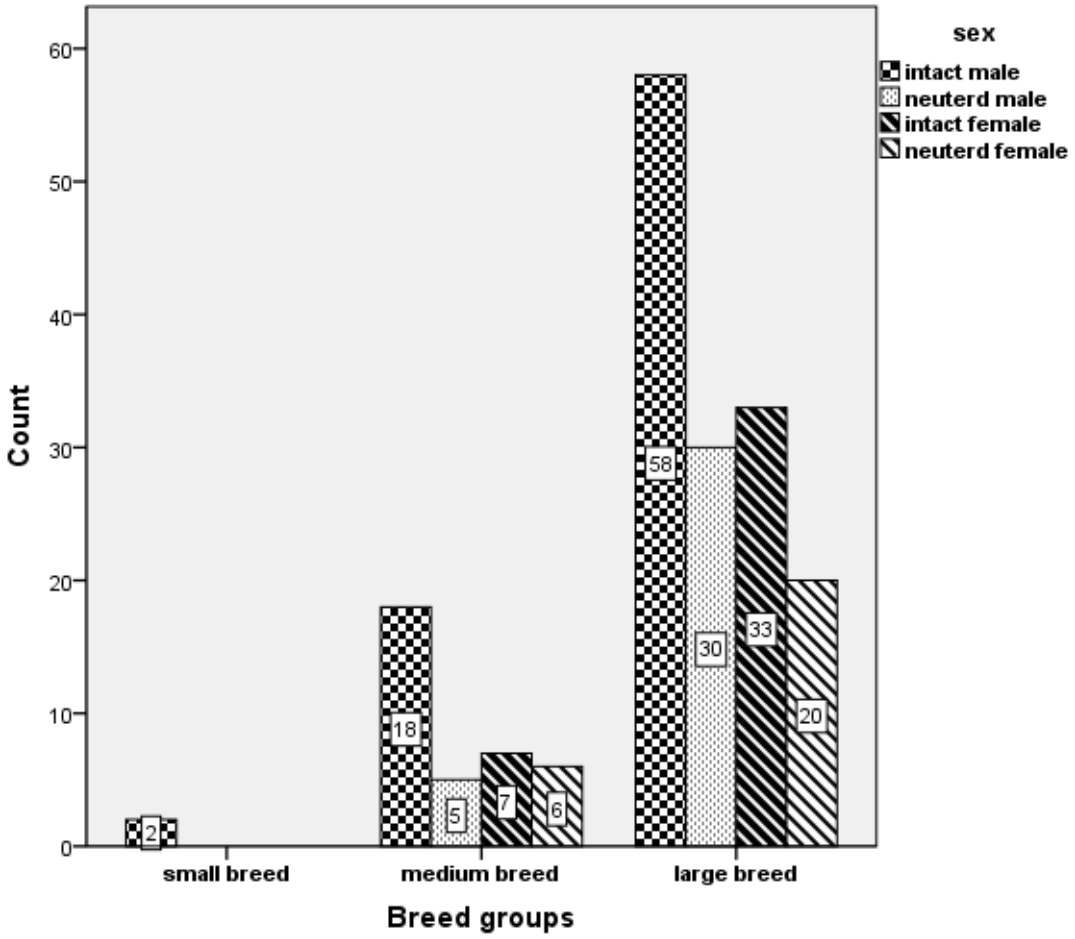

Figure 13 Breed groups and sex distribution of 181 dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

A large number of patients was received in May (11.96%) and both April and June (9.94 %) in contrary to January (3.86 %) (Table 8).

Table 8 Number and percentage of dogs with GDV-involved symptoms at the Free University of Berlin by months (2004-2009)

Month	Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
No.	**04**	2	3	1	5	3	4	5	4	2	2	9	4	**44**
No.	**05**	1	2	2	4	7	5	3	1	4	3	1	3	**36**
No.	**06**	0	0	2	5	5	2	1	7	5	3	1	1	**32**
No.	**07**	1	3	3	1	0	4	1	2	2	3	2	2	**24**
No.	**08**	3	2	3	1	4	2	2	1	5	2	2	2	**29**
No.	**09**	0	1	0	2	2	1	3	1	2	2	1	1	**19**
Total		**7**	**11**	**11**	**18**	**21**	**18**	**15**	**16**	**20**	**15**	**16**	**13**	**181**
%		**3.86**	**6.07**	**6.07**	**9.94**	**11.6**	**9.94**	**8.28**	**8.83**	**11.04**	**8.28**	**8.83**	**7.18**	

Of the total number of 181 dogs with GDV syndrome presenting to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009, 125 (69.1 %), 40 (22.1 %), and 16 (8.8 %) dogs (treatment groups) were performed gastropexy, conservative treatment and only laparotomy respectively (Table 9). Treatment groups were significantly ($\chi^2 = 61.80$, df = 2, $p = 0.00$) associated with outcome (Table 10, Figure 14).

Table 9 Treatment of dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

Treatment	Number	Per cent
Gastropexy	125	69.1
Conservative treatment	40	22.1
Laparotomy	16	8.8
Total	181	100

Table 10 Treatment groups and outcomes of 181 dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

			Outcome (discharge vs death or euthanasia)		
			Discharge	Euthanasia+deah	Total
surgery or not	surgery(gastropexy)	Count	113	12	125
		Expected Count	96.69	28.31	125.00
		% of Total	62.43	6.63	69.06
	no surgery	Count	26	14	40
		Expected Count	30.94	9.06	40.00
		% of Total	14.36	7.73	22.10
	laparotomy	Count	1	15	16
		Expected Count	12.38	3.62	16.00
		% of Total	.55	8.29	8.84
Total		Count	140	41	181
		Expected Count	140.00	41.00	181.00
		% of Total	77.35	22.65	100.00

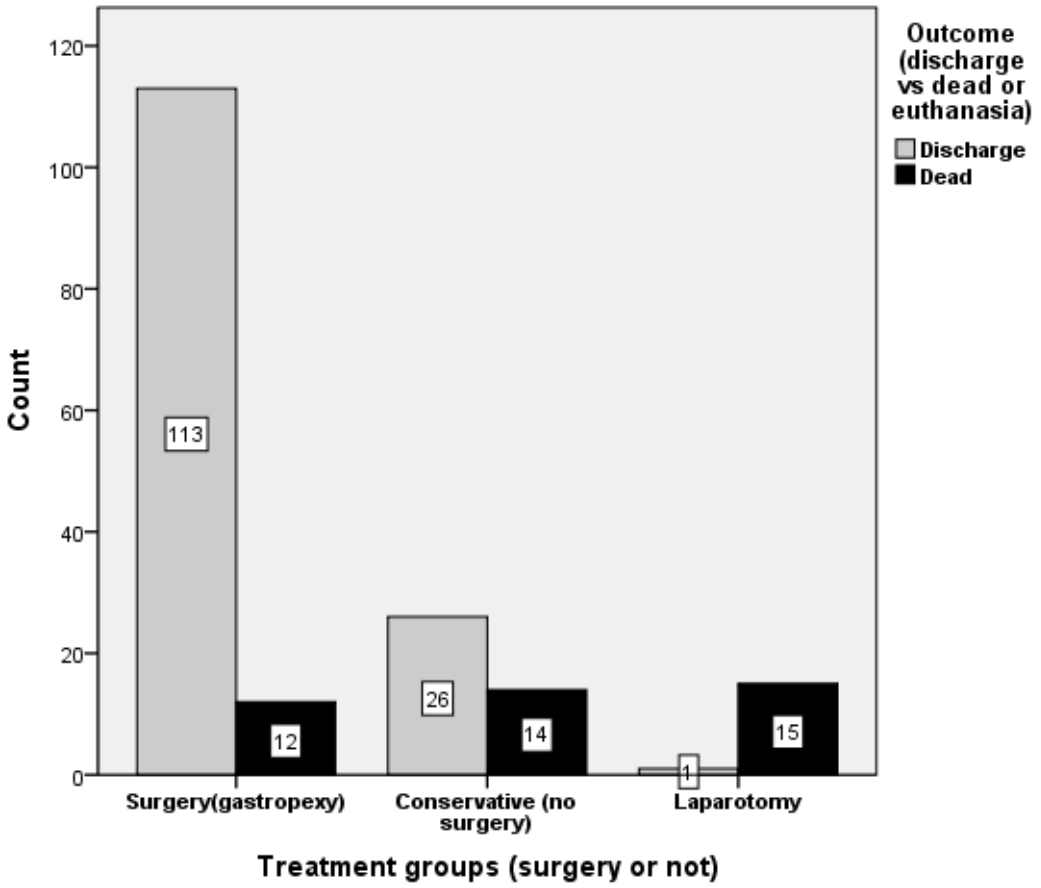

Figure 14 Treatment groups and outcomes of 181 dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

Of the total number of 125 dogs which underwent gastropexy, 113 (90.4 %) dogs were successfully treated and discharged from the hospital. Only 6 (4.8 %) dogs were euthanized due to the compromised vitality of the stomach wall, irreversible pathologic changes of the stomach and/or concurrent disease e.g. dilated cardiomyopathy. Regretfully, 6 (4.8 %) dogs were dead due to hypovolemic shock, ventricular extrasystole, splenic injury and torsion, high plasma lactate concentration or previous heart problem (Table 10).

Of the total of 40 dogs treated conservatively, 26 (65 %) were successfully treated and discharged from the hospital of the same day. However, 12 (30 %) were euthanized due

hypovolumic shock, recurrent GDV, arrythymias, previous heart problems or the owner's wish. Two dogs (5 %) died due to arrhythmia and recurrent GDV (Table 10).

Of the 16 dogs which underwent laparotomy, 15 (93.75%) dogs were euthanized due to irreversible pathologic changes of the stomach, hypovolumic shock, arrhythmias, splenic thrombosis and recurrent GDV. No dog which underwent laparotomy died. Only one (6.25 %) was discharged from the hospital after removing a foreign body from the stomach and have been hospitalized of 3 days (Table 10).

4.2 Clinical signs

According to data collected from owners, duration of the symptoms relating to GDV prior to presentation at the hospital was of an average of 2.20 hours (range: 0.5-10 hours). The median duration of clinical signs from onset to first presentation was 1.5 hours (range, 0.5-10 hours). An independent samples t-test was conducted to compare duration of clinical signs from onset to presentation between survivor group and nonsurvivor group. There was a significant difference in the duration of clinical signs for survivor groups (M=1.85, SD=1.29) and nonsurvivor group (M=2.87, SD=2.28) conditions; t(61)= -2.26, $p = 0.02$. The mean and median body weight at time of presentation were 40.43 and 38.0 kg (range: 12-80 kg) . The mean and median degree of stomach twist were 262.25 and 270 degree (range: 0-360 degree). The mean and median of hospital stay were 2.45 and 2.0 days (range: 0-10 days). An independent samples t-test was also conducted to compare the hospital stay between survivor group and nonsurvivor group. There was a significant difference in the hospital stay for survivor groups (M=2.61, SD=1.67) and nonsurvivor group (M=1.6, SD=2.29) conditions; t (160)=2.59, $p = 0.01$. The mean and median rectal temperature were 38.40 and 38.40 degree celcius (range: 35.00-40.3 degree celcius). The mean and median heart rate at presentation were 136.28 and 132.00 bpm (range: 80-200 bpm). The rest of descriptive statistics of clinical signs were shown in table 11. Clinical signs were of distending or tympanic abdomens in 112 (61.87 %), pale mucous membranes in 47 (25.96 %), tachycardia in 45 (24.86 %), respiratory distress in 37(20.44 %), dry mucous membranes in 22(12.15 %), hyperthermia in 19(10.49 %), prolonged CRT in 16(8.83 %), hypothermia in 10(5.52 %), each of heart murmur and red mucous membrane in 8(4.41 %) and cyanosis in 1 (0.55 %) dog (Table 12).

Table 11 The descriptive statistics of clinical signs

		Body weight (kg)	Duration (hrs)	Degree of stomach twist	Hospital stay (days)	Temperature (degree celcius)	Heart rate (beat/minute)
N	**Valid**	144	63	71	162	96	79
	Missing	37	118	110	19	85	102
Mean		40.43	2.20	262.25	2.45	38.49	136.28
Std. Error of Mean		1.07	.22	12.31	0.14	0.07	3.22
Median		38.00	1.50	270.00	2.00	38.40	132.00
Std. Deviation		12.80	1.74	103.72	1.81	0.72	28.62
Variance		163.76	3.02	10,757.71	3.28	0.52	818.95
Range		68.00	9.50	360.00	10.00	5.30	120.00
Minimum		12.00	0.50	0.00	0.00	35.00	80.00
Maximum		80.00	10.00	360.00	10.00	40.30	200.00

Table 12 Clinical signs of of 181 dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

Clinical signs	**N**	**%**
Distending or tympanic abdomen	112	61.87
Pale mucous membrane	47	25.96
Tachycardia	45	24.86
Dyspnea, tachypnea, polypnea	37	20.44
Dry mucous membrane	22	12.15
Hyperthermia	19	10.49
Prolonged CRT	16	8.83
Hypothermia	10	5.52
Heart murmur	8	4.41
Red mucous membrane	8	4.41
Cyanosis	1	0.55

4.3 Radiographic findings

X-ray examinations in all examined patients confirmed the suspected presence of GDV or GD. Right lateral recumbency radiographs were performed in 87.29 % (158/181) of the dogs (Table 13) of which 70.17 % (127/181) were GDV diagnosis, 16.02 % (29/181) GD diagnosis and only 1.1 % (2/181) neither GDV nor GD. However, 23 dogs (12.70 %) were not x-rayed.

Table 13 Radiographic findings of dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

Radiography/diagnosis	Number	Per cent
GDV	127	70.16
GD	29	16.02
No X-rays/ no information	23	12.70
Neither GDV nor GD	2	1.10
Total	181	99.98

Of the total number of 127 dogs with GDV confirmed by radiographs, 32 dogs had one or more associated radiographic findings of problem with their cardiovascular, gastrointestinal and/or reticuloendothelial system. The third most frequent were GDV with hypovolemic hearts (n=20), GDV with gaseous distention of the intestinal loop (n=7), and each of GDV with splenomegaly (n=4) and GDV with megaesophagus (n=4) respectively. Three dogs were GDV with foreign body.The following groups had only one dog each, they were: GDV with gaseous distention of esophagus, GDV with interstitial lung pattern, GDV with cardiomegaly, GDV with lung edema and GDV with alveolar lung pattern respectively (Table 14).

Table 14 Numbers of dogs radiographically screened for GDV and other associated radiographic findings

Radiographic findings	Number	Per cent
GDV with hypovolemic heart	25/127	19.68
GDV with gaseous distention of intestinal loop	7/127	5.51
GDV with spleenomegaly	4/127	3.14
GDV with megaesophagus	4/127	3.14
GDV with foreign body	3/127	2.36
GDV with gaseous distention of esophagus	1/127	0.78
GDV with blur cardiac silhouette	1/127	0.78
GDV with bronchial lung pattern	1/127	0.78
GDV with interstitial lung pattern	1/127	0.78
GDV with cardiomegaly	1/127	0.78
GDV with lung edema	1/127	0.78
GDV with alveolar lung pattern	1/127	0.78

4.4 Preopeative hematological and biochemical findings

4.4.1 Complete blood count

Results of complete a blood count at the initial time were available for 133 of the 141 dogs which underwent surgery. The detailed hematological results are presented in Table 15.

Table 15 Descriptive statistics of complete blood counts at initial time of dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

		WBC	RBC	Hb	Hct	MCV	MCH	MCHC	RDW	Plt
N	Valid	133	132	130	133	130	126	130	55	130
	Missing	48	49	51	48	51	55	51	126	51
Mean		12.89	6.71	15.51	44.02	65.75	23.39	34.89	15.97	245.09
Std. Error of Mean		.50	0.11	0.23	0.70	0.38	0.33	0.16	0.47	9.35
Median		11.90	6.61	15.40	43.60	65.90	23.10	35.20	15.30	231.00
Std. Deviation		5.73	1.26	2.66	8.06	4.33	3.66	1.86	3.50	106.56
Variance		32.79	1.60	7.06	64.89	18.78	13.38	3.47	12.26	11,355.60
Range		25.80	8.25	13.07	48.80	35.40	47.70	16.80	25.30	600.50
Minimum		3.90	3.36	9.33	14.80	41.30	13.50	21.30	9.50	16.50
Maximum		29.70	11.61	22.40	63.60	76.70	61.20	38.10	34.80	617.00

The main hematological abnormalities were leucocytosis (65/133; 48.87 %), anemia (40/133; 30.07 %), thrombocytopenia (22/130; 16.92 %), polycytemia (13/133; 9.77 %), leucopenia (8/133; 6.01 %), and thrombocytosis (3/130; 2.30 %) respectively. Table 16 shows the normal ranges of haematological values and percentage of cases below and above normal ranges in GDV dogs before operation.

Table 16 Normal ranges of haematological values and percentage of cases below and above normal range.

Measurement	Mean	Median	Normal range	Percentage of cases	
				Below Normal Range	above normal range
WBC	12.89	11.9	6-12	6.01	48.87
RBC	6.71	6.61	5.5-8.5	13.63	6.81
Haemoglobin	15.51	15.4	13.2-19	16.92	9.23
Haematocrit	44.02	43.6	40-55	30.07	9.77
MCV	65.74	65.9	60-77	2.30	0.00
MCH	23.38	23.1	21-27	3.17	0.79
MCHC	34.89	35.2	32-36	3.07	23.84
Platelets	245.09	231	150-500	16.92	2.30

WBC = White blood cell, RBC = Red blood cell

The leucocyte count at presentation was not significantly different in dogs that survived to discharge compared with dogs that did not survived to discharge. Hematocrit and haemoglobin values at initial time were significantly lower in dogs that survived to discharge compared with dogs that did not survive to discharge ($P = 0.05$ and 0.015). However, the red blood cell count was not significantly different between two groups.

Results of differential white blood cell count at initial time were available for 11 of the 141 dogs which underwent surgery. The detailed hematological results of differential white blood cell count are presented in Table 17.

Table 17 Descriptive statistics of differential white blood cell counts at initial time of dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

		Neu(band)	Neu(seg.)	Eo.	Baso.	Lym.	Mono.
N	**Valid**	9	11	4	0	11	11
	Missing	172	170	177	181	170	170
Mean		3.78	86.18	1.75		5.36	4.73
Std. Error of Mean		1.61	1.97	.25		.96	1.18
Median		2.00	86.00	2.00		4.00	4.00
Std. Deviation		4.82	6.54	.50		3.17	3.90
Variance		23.19	42.76	.25		10.05	15.22
Range		15	24	1		11	9
Minimum		1	70	1		1	1
Maximum		16	94	2		12	10

4.4.2 Coagulation profiles

Results of coagulation profiles (aPTT, PT(%), PT(sec), and AT III) at initial time were available for 49, 59, 48 and 5 of the 141 dogs which underwent surgery. The detailed coagulation profile results are presented in Table 18. The main coagulation profile abnormalities were of prolonged aPTT and PT(sec) in 40.81 % and 18.75 %, respectively, compared to their normal ranges.

Table 18 Descriptive statistics of coagulation profiles at initial time of dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

		aPTT(sec)	PT(%)	PT(sec)	AT III
N	**Valid**	49	59	48	5
	Missing	132	122	133	176
Mean		24.11	70.29	21.74	88.56
Median		23.50	79.00	20.25	88.20
Std. Deviation		5.40	42.38	6.47	16.83
Variance		29.15	1,795.73	41.85	283.29
Range		25,2000	150	36,6000	43,5000
Minimum		11,9000	0	13,4000	71,5000
Maximum		37,1000	150	50,0000	115,0000

An independent-samples t-test was conducted to compare the coagulation profile at presentation between survivor and nonsurvivor groups. There was a significant difference in aPTT(sec) in survivor group (M=23.25, SD=4.91) and nonsurvivor group (M=30.21, SD=5.06) conditions; t(47)= -3.23, $p = 0.02$. There was a significant difference in PT (%) in survivor group (M=78.00, SD=39.85) and nonsurvivor group (M=32.50, SD=34.50) conditions; t(57)= 3.35, $p = 0.01$. There was a significant difference in PT (sec) in survivor group (M=20.38, SD=4.18) and nonsurvivor group (M=31.21, SD=11.25) conditions; t(46)= -4.58, $p = 0.00$.

Table 19 shows the normal ranges of coagulation profile values and percentage of cases below and above normal ranges in GDV dogs before operation.

Table 19 Normal ranges of coagulation profile values and percentage of cases below and above normal range

Measurement	Mean	Median	Normal range	Percentage of cases	
				Below Normal Range	above normal range
aPTT (sec)	24.1	23.50	14-25	2.04	40.81
PT (%)	70.29	79.00	65-130	18.75	4.16
PT (sec)	21.74	20.25	15.5-26	6,25	18.75
AT III	88.56	88.20			

4.4.3 Biochemical finding

Result of each plasma electrolyte at initial time was available for 30 to 129 of the 141 dogs underwent surgery. The detailed results are presented in Table 20.

Table 20 Descriptive statistics of plasma electrolytes at initial time of dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

	N	Range	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Na	129	29,00	136,00	165,00	146,86	,40	4,49
K	133	4,11	2,35	6,46	3,76	,05	,54
Ca++	30	,37	1,14	1,51	1,27	,02	,09
Ca	63	2,65	1,25	3,90	2,58	,05	,39
P	76	3,18	,59	3,77	1,36	,06	,48
Bun	111	193,50	13,90	207,40	39,50	2,06	21,74
Mg	24	,72	,45	1,17	,78	,03	,15
Glu	127	256,00	48,00	304,00	129,11	3,17	35,76
Valid N (listwise)	3						

An independent-samples t-test was conducted to compare the plasma electrolyte at presentation between survivor and nonsurvivor groups. There was a significant difference in ionized calcium in survivor group (M=1.25, SD=0.06) and nonsurvivor group (M=1.33, SD=0.13) conditions; t(28)= -2.10, $p = 0.04$ The results of the rest of electrolytes show no significant difference in each electrolyte between survivor group and nonsurvivor group.

Table 21 shows the normal ranges of plasma electrolytes and percentage of cases below and above normal ranges in GDV dogs before operation.

Table 21 Normal ranges of plasma electrolytes and percentage of cases below and above normal ranges in GDV dogs before operation

Measurement	**Mean**	**Normal range**	**Percentage of cases**	
			Below Normal Range	**above normal range**
Sodium	146.86	140-150	1.55	17.82
Potassium	3.76	3.6-4.8	35.33	2.25
Glucose	129.11	81-112	2.36	59.05
Ionized calcium	1.27			
Calcium	2.58	2.5-2.9	30.15	6.34
Phosphorus	1.36	0.96-1.6	11.84	18.42
Magnesium	0.78			

Result of each blood chemistry at initial time were available for 1 to 111 of the 141 dogs underwent surgery. The detailed results are presented in Table 22.

Table 22 Descriptive statistics of blood chemistries at initial time of dogs presenting with GDV syndrome to the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

	N	Range	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
BUN	111	193,50	13,90	207,40	39,50	2,06	21,74
Creatinine	107	3,71	,50	4,21	1,16	,05	,55
ALT	84	2681,97	1,03	2683,00	207,13	53,20	487,60
AP	81	3113,00	17,00	3130,00	135,41	38,57	347,17
AST	79	11893,00	13,00	11906,00	297,54	151,52	1346,74
GLDH	77	264,00	,00	264,00	14,82	4,06	35,63
Pro	107	5,95	2,85	8,80	6,08	,11	1,13
Alb	81	2,23	1,47	3,70	2,72	,05	,43
Bili	80		,07	0,43	0.20		
Chorester	51	359,73	,27	360,00	209,52	9,06	64,69
CK	9	1980,00	236,00	2216,00	846,89	231,57	694,70
Triglyceride	6	23,00	27,00	50,00	37,50	4,10	10,03
Chloride	17	22,00	97,00	119,00	108,09	1,31	5,38
Myoglobin	1	,00	40,00	40,00	40,00	.	.
Lactate	19	10,90	,90	11,80	6,36	,66	2,87
Valid N (listwise)	0						

Table 23 shows the normal ranges of blood chemistries and percentage of cases below and above normal ranges in GDV dogs before operation.

An independent-samples t-test was conducted to compare blood chemistries at presentation between survivor and nonsurvivor groups. There was a significant difference in plasma ALT in survivor group (M=132.20, SD=310.01) and nonsurvivor group (M=831.55, SD=1042.32) conditions; t(82)= -4.51, $p = 0.00$. There was a significant difference in plasma AST in survivor group (M=114.11, SD=155.82) and nonsurvivor group (M=2184.14, SD=4328.36) conditions; t(77)= -4.29, $p = 0.00$. There was a significant difference in plasma GLDH in

survivor group (M=10.06, SD=19.80) and nonsurvivor group (M=62.43, SD=93.07) conditions; t(74)= -4.06, *p = 0.00*.

Table 23 Normal ranges of blood chemistries and the percentage of cases below and above normal ranges in GDV dogs before operation

Measurement	Mean	Normal range	Percentage of cases	
			Below Normal Range	above normal range
BUN	39.5	21-60	11.71	8.10
Creatinine	1.16	0.6-1.4	1.86	17.75
ALT	207.13	0-76	0.00	41.66
AP	135.41	0-97	0.00	34.56
AST	297.54	0-41	0.00	73.41
GLDH	14.82	0-8.6	0.00	33.76
Protein	6.08	5.4-6.6	24.99	36.44
Albumin	2.72	2.8-3.6	49.38	1.23
Bilirubin	1.12	0-0.3	0.00	12.50
Choles	209.52			
CK	846.89	0-182	0.00	100.00
Triglyceride	37.5			
Chloride	108.09	98-108	5.88	52.94
Lactate	6.36			
Amylase	825.25	0-1850	0.00	0.00
Lipase	427.23	0-250	0.00	61.53

BUN = Blood urea nitrogen, ALT = Alanine aminotransferase, AP = Alkaline phosphatase, AST = Aspartate aminotransferase, GLDH = Glutamate dehydrogenas, CK = Creatine kinase

4.5 Surgical finding

Of the total number of 141 dogs which underwent either gastropexy or laparotomy, 119 (84.39 %) dogs had pathologic changes in one or more parts of the stomach (Table 24). The report of pathologic changes were not available in 22 dogs. Areas of pathologic changes were significantly ($\chi^2 = 49.04$, df = 8, *p = 0.00*) associated with an outcome of overall morbidity.

Table 24 Area of pathologic change at the stomach and outcome of of 119 dogs underwent either gastropexy or laparotomy at the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

			Outcome (discharge vs death or euthanasia)		
			Discharge	**Death**	**Total**
Area of pathologic change of the stomach	**Cardiac part**	Count	18	3	21
		Expected Count	16.76	4.24	21.00
		% of Total	15.13	2.52	17.65
	Fundus part	Count	12	2	14
		Expected Count	11.18	2.82	14.00
		% of Total	10.08	1.68	11.76
	Body	Count	1	0	1
		Expected Count	.80	.20	1.00
		% of Total	.84	.00	.84
	Cardiac part+fundus part	Count	9	8	17
		Expected Count	13.57	3.43	17.00
		% of Total	7.56	6.72	14.29
	Cardiac part+pyloric part	Count	1	0	1
		Expected Count	.80	.20	1.00
		% of Total	.84	.00	.84
	Cardiac part+fundus part+body	Count	0	6	6
		Expected Count	4.79	1.21	6.00
		% of Total	.00	5.04	5.04
	Cardiac part+fundus part+body+pylor ic	Count	0	2	2
		Expected Count	1.60	.40	2.00
		% of Total	.00	1.68	1.68
	Pathologic changes, area unknown	Count	32	3	35
		Expected Count	27.94	7.06	35.00
		% of Total	26.89	2.52	29.41
	Normal	Count	22	0	22
		Expected Count	17.56	4.44	22.00
		% of Total	18.49	.00	18.49
Total		Count	95	24	119
		Expected Count	95.00	24.00	119.00
		% of Total	79.83	20.17	100.00

Of the total number of 141 dogs which underwent either gastropexy or laparotomy, 71 dogs were noted for the degree of stomach twist. The mean degree of stomach twist was 262.25 degree (n=71).

4.6 Outcomes

Of these 181 GDV-involved symptomatic patients, 125 (69.06 %) dogs underwent gastropexy, survived and were discharged from the hospital (Table 25). After surgery the animals were kept and treated intensively in the ward for an average of 3.07 days until discharge, euthanasia or death. Unfortunately, 6 (4.8 %) out of 125 dogs died after surgery. No dogs died during the first day after surgery. Two dogs (1.6 %) died on the second and fourth day after surgery, respectively. Each dog (0.8 %) died on the third and fifth day after surgery, respectively.

Table 25 Survival and mortality data in 125 dogs underwent general anesthesia and surgery for correction of GDV (gastropexy) at the Clinic for Small Domestic Animals, Free University of Berlin, Germany between 2004 and 2009

Category	No. of dogs
1. Discharge from hospital after stabilization	113
2. Euthanasia during peri-operative period	1
3. Euthanasia during post-operative period	5
4. Died during during peri-operative period	0
5. Died during post-operative period	6
Total	125

4.7 Complications

Eight dogs developed ventricular extrasystole (VES) postoperatively. However they were given intensive treatment with lidocaine and any other necessary medications. All of them survived and were discharged from the hospital. Methicillin-resistant *Staphylococcus aureus* (MRSA) infection was identified in one dog during hospitalization. However, it was successfully treated with proper antibiotics. Finally, the dog survived and was discharged from the hospital.

4.8 Previous surgery or sickness (Table 26)

Thirty-six patients (19.88 %) had one or more previous surgeries or associated diseases of inflammatory origin, tumor or degeneration . The third most frequent were gastrointestinal system (n=12), cardiovascular system (n=8), and musculoskeletal system (n=3). Of the 36 patients with associated diseases, 32 patients had one associated disease, 2 patients had two, and 2 patients had three.

Table 26 Previous surgery or sickness in 36 patients with GDV-involved symptom patients

Previous surgery or sickness	**n (%)**
1.Tumor	2
- Perianal tumor, mass at prepuce (1)	
- Masses at tail and hind limb (1)	
2. Gastrointestinal system	12
- GDV operation (gastropexy) (6)	
- GD (conservative treatment) (2)	
- Gastritis (1)	
- Megaesophagus (1)	
- Rectoscopy (1)	
- Hematoschezia (1)	
3. Integument system	2
- Massive dermatitis (1)	
- Skin problem (1)	
4. Urogenital system	2
- Prostate problem (1)	
- Perineal hernia operation (1)	
5. Musculoskeletal system	4
- Spodylosis (1)	
- Hip problem (2)	
- Muscular atrophy (1)	
6. Cardiovascular system	8
- Cardiomegaly (1)	
- Homeopathic treatment for the heart (1)	
- DCMP (2)	
- Heart patients (4)	
7. Reticoloendothelial system	2
- Spleen torsion operation (1)	
- Suspect of spleen torsion (refer) (1)	
8. Tumor + Musculoskeletal system	1
- Testiculat tumor + lameness (1)	
9. Gastrointestinal system (2x) + Exocrine system	1
- GDV operation + intestinal rupture + pancreatic insufficiency (1)	

Table 26 (continue) Previous surgery or sickness in 36 patients with GDV-involved symptom patients

Previous surgery or sickness	n (%)
10. Musculoskeletal system + Hepatobiliary system	1
- Cervical vertebral problem + hepatopathy (1)	
11. Gastrointestinal system + Cardiovascular system + Endocrine system	1
- GDV operation + heart insufficiency + hypothyroid (1)	
Total	**36**

5. Discussion

In this retrospective study, we characterize the clinical course of and identify prognostic indicators for canine GDV that could affect the survival or mortality rate. Canine GDV is a potentially life-threatening problem. Immediate, proper emergency medical treatment follow by prompt definitive surgical treatment, as well as, intensive post-operative care is required. The main objectives of the surgery to treat GDV are decompression and repositioning of the stomach, resection of any pathologic gastric wall, and prophylactic permanent gastropexy. Methods for GDV surgery include tube gastropexy, circumcostal gastropexy, muscular flap (incisional) gastropexy, belt-loop gastropexy, incorporating gastropexy, gastrocolopexy, laparoscopic prophylactic gastropexy and minilaparotomy prophylactic gastropexy. However, incorporating gastropexy is chosen as a surgical treatment of choice in our hospital, because this technique is simple and can be learned and performed easily. This technique takes shorter surgical time which diminishes the risk of anesthetic complications (MEYER-LINDENBERG et al., 1993). Normally, gastrostomy is not performed in this method. Therefore, gastric decompression should be early performed by preoperative percutaneous decompression, peri-operative orogastric intubation, or direct gastric puncture with a large-bore catheter connected to the suction line. If gastric decompression is still not successfully performed and the stomach needs to be decompressed and drained, ventral marsupialization can be alternatively performed to achieve gastric decompression and drainage. Ventral marsupialization is expected to result in an effective permanent gastropexy with adhesions between the stomach wall and the ventral abdominal wall in the second surgery. MILLS et al. (2000) reported that GDV in two large breed dogs was successfully treated with ventral marsupialisation. The sex distribution of dogs in the present study was similar to sex distributions reported in previous studies (MEYER-LINDENBERG et al., 1993; BROCKMAN et al., 1995; DE PAPP et al., 1999; BECK et al., 2006 and BUBER et al., 2007) which show male dogs present slightly more than female dogs. However, Green et al (2011) have shown a markedly higher ratio of male to female (2.78:1) compared to this study (1.72:1). The reason for this difference might be because of more exclusion criteria. Older dogs are normally at higher risk of developing GDV. The association between an older dog and morbidity is pronounced in our study. The result of dog population relative to age in our study is similar to former studies (MEYER-LINDENBERG et al., 1993; BROCKMAN et al., 1995; DE PAPP et al., 1999; BECK et al., 2006; BUBER et al., 2007). Only six patients (3.4 %) presented at our hospital before the age of two years. In human medicine, gastric volvulus is a rare condition. The cause of gastric volvulus in the newborn is congenital diaphragmatic defect. Whereas, the cause of gastric volvulus in the elderly is increasing laxity of the supporting structures of the stomach (MILNE et al., 1993). In human, structures connected to

the stomach include the gastrophrenic, gastrohepatic, gastrosplenic, and gastrocolic ligaments. The stomach is held in place at the esophageal hiatus and pylorus by these four ligaments (CAMERON and Howard, 1987). In a dog, the stomach is loosely held in place by its attachments to the esophagus and diaphragm and duodenum. Ligaments connected to the dog's stomach are hepatoduodenal, hepatogastric, and gastrosplenic (EVANS, 1993). Certain large- and giant-breed dogs, dogs with a large thoracic depth-to-width ratio, dogs with lower body condition score, and older animals are at higher risk of developing GDV (GLICKMAN et al., 2000[a]; GLICKMAN et al., 2000[b]; SCHAIBLE et al.,1997). These include the Great Dane, the Saint Bernard, the Weimaraner, the Irish Setter, the Gordon Setter , the Standard Poodle, and the Basset Hound. Large, mixed-breed dogs also are at higher risk compared to small, mixed-breed dogs (GLICKMAN et al., 1994; GLICKMAN et al., 1997). The most common breeds in this study were the German Shepherd, large mixed-breed and the Great Dane respectively which is similar to previous studies (Brockman et al., 1995; De Papp et al., 1999; Beck et al., 2006; MACKENZIE et al., 2010). Furthermore, standard poodles are common in those previous studies but the least common (0.6%) in our study. GDV dogs are commonly large or giant breeds and consequently have more weight. The mean and median body weights (40.43 and 38.00 kg, range 12-80 kg) at the time of presentation in our study were similar to previous studies (GLICKMAN et al., 1997; BUBER et al., 2007). The association between treatment groups and outcome are pronounced in our study. Treatment groups included a gastropexy group, a conservative treatment group (no surgery) and a laparotomy group. Outcome was defined as either survival to discharge, or dead and/or euthanasia. Overall survival for this study was slightly lower (77.35 %) than previous study (88 %) of Green et al., (2011), however, there were less subjects and more exclusion criteria than in our study. Survival in the surgically treated group (gastropexy) was higher (90.4 %) than in previous study (79.7 %) (MEYER-LINDENBERG et al., 1993). In our study, only 4.8 % of dogs with a performed surgical gastropexy were euthanized due to compromised vitality of the stomach wall, irreversible pathologic changes of the stomach and/or some concurrent disease e.g. dilated cardiomyopathy. In addition, 4.8 % of dogs with a performed surgical gastropexy died due to hypovolemic shock, ventricular extrasystole, splenic injury and torsion, high plasma lactate concentration or previous heart problem. Of the conservatively treated group in our study, the survival rate was slightly lower (65 %) compared to previously reported data (75.75 %) (MEYER-LINDENBERG et al., 1993). The reason for this difference might be because of a greater number of necessary euthanasias. The reasons for euthanasia in these dogs were hypovolumic shock, recurrent GDV, arrhythmias, previous heart problem or the owner's wish. Duration of the symptoms related to GDV prior to presentation at the hospital was of an average of 2.20 hours (range: 0.5-10 hours). The median duration of clinical signs from onset to first presentation was 1.5 hours (range, 0.5-10 hours). The mean and median duration of clinical signs from onset to first presentation were

slightly shorter to previously reported data (BROCKMAN et al., 1995; BECK et al., 2006; BUBER et al., 2007; ADAMIK et al., 2009). Generally, the rotation of the stomach is in a clockwise manner when viewed from the surgeon's perspective (with the dog on its back and the clinician standing at the dog's side, facing cranially). The rotation may be 90 to 360 degrees but usually is 220 to 270 degrees (Fossum et al., 2006) In this study, the mean and median degree of stomach twist were 262.25 and 270 degree (range: 0-360 degree). Clinical signs present in this study included distending or tympanic membrane, pale mucous abdomen, tachycardia, respiratory distress, dry mucous membrane, hyperthermia, prolonged CRT, hypothermia, heart murmur, red mucous membrane, and cyanosis. Radiographic application for the diagnosis of GDV is widely established. It is necessary to differentiate gastric dilatation alone from gastric dilatation and volvulus. Affected animals should be decompressed before radiographs are taken. If an unstable animal is forced to take a radiography, it will be probably go into shock and die on the X-ray table. A right lateral abdominal radiographic view has been recommended for the best appearance of GDV. Of the total number of 127 radiographically performed dogs, with GDV confirmed, 32 dogs had one or more associated radiographic findings of cardiovascular, gastrointestinal and reticuloendothelial system. The third most frequent findings were GDV with hypovolemic heart, GDV with gaseous distention of the intestinal loop, and each of GDV with splenomegaly and GDV with megaesophagus respectively which agree with the finding of the previously reviewed article (BISCHOFF, 2003). Early hematologic characteristic probably reveals a stress leucogram, in which leukocytosis with lymphopenia can be observed . The advanced endotoxemic shock patient have sometimes a reduction of polymorphonuclear leucocytes present on the complete blood cell count (MONET, 2003). Anemia is common as well as thrombocytopenia. In this study, leukocytosis and leucopenia were 48.87 % and 6.01 % respectively. Additionally, 30.07 % of dogs had reductions of packed cell volume and 16.92 % of dogs had thrombocytopenia. Leucocyte count at presentation was not significantly different in dogs that survived to discharge compared with dogs that did not survived to discharge. Hematocrit and haemoglobin values at initial time were significantly lower in dogs that survived to discharge compared with dogs that did not survived to discharge ($P= 0.05$ and 0.015). It might be because of hemoconcentration of shock patients. It has been found in our study that there were significant differences in aPTT, PT(sec), and PT(%) between survivor group and nonsurvivor group. These results suggest that coagulation parameters really do have an effect on survival. Specifically, our results suggest that when GDV dogs have prolonged aPTT and PT, their survival decrease. Characteristics of biochemistry panels show electrolyte abnormalities with hypokalemia, increased plasma lactate, biliary stasis, liver damage, and prerenal or renal azotemia (MONET, 2003). In our study, although the mean preoperative plasma potassium concentration was in normal range (mean=3.76; normal range= 3.6-4.8), hypokalemia was

found in as high as 35.33 % of cases. Mean preoperative plasma lactate concentration in our study was 6.36 mmol/L. It is slightly lower than the cut-off level (6.6 mmol/L) which was reported as an indicator of stomach necrosis (DE PAPP et al., 1999). However, there were as high as 42.10 % of cases that had preoperative plasma lactate concentration higher than 6.6 mmol/L(cut-off level) in our study. We have not compared the outcomes between an increased plasma lactate group (> 6.6 mmol/L) and a decreased plasma lactate group (< 6.6 mmol/L) statistically because the number of patients was too small (19 cases). All 11 patients in a decreased plasma lactate group (< 6.6 mmol/L) survived to discharge. Only 5 patients in an increased plasma lactate group (> 6.6 mmol/L) survived to discharge, 2 were euthanized and 1 died. In our study, there were significant differences in ALT, AST, and GLDH between survivor group and nonsurvivor group. These results suggest that liver enzymes really do have an effect on survival. Specifically, our results suggest that when GDV dogs have increased ALT, AST, and GLDH, their survival decrease. An area of pathologic change in the stomach usually located along the greater curvature of the fundus and often extend to the cardia. Results of areas of pathologic changes in our study suggest that dogs with pathologic changes only one area in stomach have greater outcome than dogs with pathologic changes more than one areas in stomach. In our study, only 3 of 21 (14.28 %) and 2 of 14 (14.28 %) dogs with necrosis of the cardia and fundus, respectively, died or euthanized. In contrast, all 6 dogs (100 %) with necrosis of cardia, fundus and body died or euthanized. Additionally, both 2 dogs (100 %) with necrosis of cardia, fundus, body and pylorus also died or euthanized. Normally, antibiotic is routinely administered to a GDV dog as both a prophylaxis and postoperative treatment in our clinic. Bacterial infection and/or bacteremia can occur if proper antibiotic is not given pre- and post-operatively. Many risk factors can cause the bacterial infection and/or bacteremia in a GDV dog. They include venous and arterial access, compromised reticulo-endothelial system, and reticuloendothelial dysfunction and/or endotoxemia (WINKLER et al., 2003). Of the total number of GDV patients, only one dog had bacteremia from MRSA infection. However, it was successfully treated with proper antibiotics. Finally, the dog survived and was discharged from the hospital. WINKLER et al., 2003 concluded that bacteremia did not appear to influence survival in their study. However, there were only 21 GDV dogs. The greater sample size in the future study may show more interesting result.

6. Summary

Gastric dilatation-volvulus (GDV) is a potentially life-threatening syndrome of multifactorial origins that require immediate appropriate medical and surgical treatment as well as intensive postoperative care. Many studies have shown multiple risk factors for GDV. They include breed, anatomy, genetics, age, feeding, activities, behaviors and other factors. Surgery should be performed as soon as the GDV dogs have been treated medically and are stable enough to be given general anesthesia. The principal objectives of surgical treatment are decompression and repositioning of the stomach, resection of a possible pathologic gastric wall, and prophylactic permanent gastropexy. In our clinic, a surgical method of choice is 'Incorporating gastropexy'. We use this technique routinely because this technique is technically simple and can be learned and performed easily. Additionally, this technique takes less surgical time which diminishes the risk of anesthetic complications. The sex distribution of dogs in our study shows that male dogs present slightly more than female dogs with male to female ratio 1.72:1. The result of dog population relative to age in our study is similar to former studies which older dogs are more common. Fourty-three breeds were represented in our clinic during the six years. The fourth most frequent breeds include the German Shepherd (10.4 %), the Great Dane (7.5 %) and large mixed breed (7.5 %), and the Dobermans (6.4 %), respectively. The third most frequent clinical signs are of distending or tympanic abdomens in 112 (61.87 %), pale mucous membranes in 47 (25.96 %), and tachycardia in 45 (24.86 %), respectively. Thirty-two dogs have one or more associated radiographic findings of problem with their cardiovascular, gastrointestinal and/or reticuloendothelial system. The third most frequent were of GDV with hypovolemic hearts, GDV with gaseous distention of the intestinal loop, and each of GDV with spleenomegaly and GDV with megaesophagus, respectively. Of the 181 GDV-involved symptomatic patients, 125 (69.06 %) dogs were performed gastropexy. Of these 125 dogs underwent gastropexy, 113 (90.40 %) dogs survived and were discharged from the hospital. Of the 181 GDV-involved symptomatic patients, 40 (22.22 %) dogs were treated conservatively. Of these 40 dogs underwent conservative treatment, 26 (65 %) dogs were successfully treated and discharged from the hospital. Of the 181 GDV-involved symptomatic patients, 16 (19.75 %) dogs were performed laparotomy. Of these 16 dogs underwent laparotomy, 15 (93.75%) dogs were euthanized due to irreversible pathologic changes of the stomach, hypovolumic shock, arrhythmias, splenic thrombosis and recurrent GDV. No dog which underwent laparotomy died. Only one (6.25 %) was discharged from the hospital after removing a foreign body from the stomach and it has been hospitalized

of 3 days. In this study, overall survival and survival in the surgically treated group (gastropexy) are 77.35 % and 90.4 %, respectively. It might be concluded that coagulation parameters (aPTT and PT), liver enzymes (ALT, AST, and GLDH), plasma ionized calcium, and duration of clinical signs from onset to first presentation are prognostic indicators for survival and mortality. According to the 90.40 % survival rate of surgically treated group (incorporating gastropexy), this technique seem to be more practical to the surgeon to perform the immediate surgical correction of GDV.

7. Zusammenfassung

Magendrehung beim Hund
– Retrospektive Studie zur inkorporierenden Gastropexie –

Die Torsio ventriculi ist ein potentiell lebensbedrohliches Syndrom multifaktorieller Entstehung, das sowohl eine dringende entsprechende medizinische und chirurgische Behandlung als auch eine intensive postoperative Überwachung/Betreuung erfordert. In verschiedenen Studien sind die vielfältigen Risikofaktoren für die Torsio ventriculi aufgezeigt worden. Darunter Rasse, Anatomie, genetische Disposition, Alter, Ernährung, Temperament, Verhalten und andere mehr. Operationen sollten durchgeführt werden, sobald die betroffenen Hunde medizinisch behandelt und stabil genug für eine Vollnarkose sind.

Die grundlegenden Prinzipien der chirurgischen Intervention sind Entlastung und Reposition des Magens, die Resektion eventuell pathologisch veränderter Magenwand und die prophylaktische permanente Gastropexie. Eine Methode der Wahl in unserer Klinik ist die „inkorporierende Gastropexie“. Sie wird routinemäßig angewandt, weil sie technisch einfach ist und leicht erlernt und ausgeführt werden kann. Außerdem braucht diese Technik eine verhältnismäßig kurze Operationszeit und vermindert somit das Risiko von Narkosekomplikationen.

Die Geschlechterverteilung der Hunde in unserer Untersuchung zeigt, dass männliche Hunde etwas häufiger betroffen waren als weibliche, mit einem Verhältnis von 1,72:1. Bezogen auf das Alter der Tiere ergab unsere Studie ähnliche Ergebnisse wie vorhergehende Studien, wobei ältere Hunde häufiger betroffen sind. 43 Rassen kamen in unserer Klinik während der sechs betrachteten Jahre vor. Die vier häufigsten sind Deutscher Schäferhund (10,4%), Deutsche Dogge (7,5%), große Mischlinge (7,5%) und Dobermann (6,4%). Die drei häufigsten klinischen Zeichen sind pralles oder aufgeblähtes Abdomen bei 112 (61,87%), blasse Schleimhaut bei 47 (25,96%) und Tachycardie bei 45 (24,86%) Tieren. 32 Hunde haben einen oder mehrere begleitende radiologische Befunde im kardiovaskulären System, Magen-Darm-System und/oder retikuloendothelialen System. Die drei häufigsten Befunde waren hypovolämisches Herz, aufgegaste Darmschlingen sowie gleichermaßen häufig Splenomegalie und Megaösophagus. Von den 181 Torsio ventriculi betroffenen Patienten erhielten 125 (69,06%) eine Gastropexie. Von ihnen überlebten 113 (90,40%) und wurden aus der stationären Betreuung entlassen.

Von den 181 Patienten mit Torsio ventriculi Symptomatik wurden 40 (22,22%) konservativ behandelt. Von diesen 40 Hunden mit einer konservativen Therapie wurden 26 (65%) erfolgreich behandelt und aus der Klinik entlassen. Von den 181 Tieren der Gesamtgruppe erhielten 16 (19,75%) eine Laparotomie. Von diesen mussten 15 (93,75%) euthanasiert werden aufgrund von irreversibler pathologischer Veränderungen des Magens, hypovolämischen Schocks, Arrhythmie, Milzthrombose oder rezidivierender Torsio ventriculi. Keines der laparotomierten Tiere verstarb.

Nur ein Hund wurde nach Entfernung eines Fremdkörpers aus dem Magen aus der Klinik entlassen, nach dreitägiger stationärer Behandlung. Von den in dieser Studie betrachteten Hunden haben 77,35% insgesamt überlebt und 90,4% der operierten Tiere (Gastropexie). Es kann geschlussfolgert werden, dass Gerinnungsparameter (aPTT und PT), Leberenzyme SGPT, SGOT, GLDH), ionisiertes Calcium im Plasma und die Dauer der klinischen Zeichen von Beginn bis zur ersten Vorstellung Prognoseindikatoren für die Überlebensrate und Mortalität sind. Aufgrund der Überlebensrate von 90,40% der operativ behandelten Gruppe (inkorporierende Gastropexie) scheint diese Operationstechnik für den Chirurgen die praktischere Methode zur operativen Korrektur der Torsio ventriculi zu sein.

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10. Selbständigkeitserklärung:

Hiermit bestätige ich, dass ich die vorliegende Arbeit selbständig angefertigt habe.

Ich versichere, dass ich ausschließlich die angegebenen Quellen und Hilfen Anspruch genommen habe.

Berlin, den 26 November 2012

Kriangkrai Thongkorn