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Jacobs Journal of Veterinary Science and Research

Research Article

Occurrence and Factors affecting Chronic Gastrointestinal Signs after Acute Gastric Dilatation-Volvulus Surgery in Dogs

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Received: 09-01-2015

Accepted: 09-19-2015

Published: 11-02-2015

Abstract

To date, several studies have assessed risk factors for the development of gastric dilatation-volvulus (GDV) in dogs. However, the association between chronic gastrointestinal (GI) signs and acute GDV has rarely been investigated. The purpose of this retrospective case-control study was to investigate the occurrence of chronic GI signs in 103 dogs after acute GDV surgery performed between January 2004 and May 2008 and to identify possible risk factors associated with such signs. After GDV surgery, 54.4 % of the dogs suffered from at least one chronic GI sign. In the final multiple logistic regression model, the pre-surgical factor that significantly associated with an increased risk of chronic GI signs after GDV surgery was the presence of such signs before surgery (OR 3.20, p = 0.010). Conversely, receiving table scraps before (OR 0.31, p < 0.01) or after (OR 0.25, p = 0.043) surgery compared to not receiving table scraps was sig-nificantly associated with a decreased risk of chronic GI signs or renewed dilatation after surgery, respectively. Older dogs (OR 0.88, p = 0.023) had a lower risk of renewed dilatation after surgery.

Keywords: Chronic Gastrointestinal Signs; Gastric dilatation volvulus; Long-term outcome; Dog; Risk factors

Abbreviations

GDV: Gastric Dilatation Volvulus;
GI: Gastrointestinal;
ICU: Intensive Care Unit;
NSAID: Non-steroidal Anti-Inflammatory Drug;
AUC: are under the curve;
CI: Confidence Interval;
OR: Odds Ratio;
IBD: Inflammatory Bowel Disease;
EPI: Exocrine Pancreatic Insufficiency

Introduction

Gastric dilatation-volvulus (GDV) syndrome in dogs is an acute, life-threatening condition primarily affecting large and giant breed dogs [1, 2], with the following breeds being considered as GDV predisposed: Great Dane, German Shepherd, Doberman Pinscher, Standard Poodle, St Bernard, Irish Setter, Weimaraner, Gordon Setter, Bloodhound, Irish Wolfhound and Akita [1-3]. The condition is characterized by the rapid accumulation of air in the stomach (dilatation), rotation of the stomach on its long axis (volvulus), and increased intragastric pressure. Decreased venous return alters the hemodynamics of the body, which can result in cardiogenic shock and death. Despite aggressive medical and surgical treatment, mortality in dogs with GDV ranges from 10 % to 33.3 % [1, 2, 4-10].

The etiology and pathogenesis of GDV are not fully understood. Several studies have been conducted to determine the risk factors for the development of the disease [1, 6, 7, 11-16]. However, chronic gastrointestinal (GI) signs in dogs suffering from an acute GDV event have rarely been examined. The purpose of this study was to investigate the occurrence of chronic GI signs after acute GDV surgery and to model possible risk factors associated with them. Risk factors associated with renewed dilatation were also modelled. Chronic GI signs observed in this study were vomiting, diarrhea, dilatation, borborygmus, abdominal pain, flatulence, and eructation.

Materials and Methods

In this case-control study, disease, surgical and clinical data on GDV-operated dogs were obtained retrospectively from the electronic patient database of the Veterinary Teaching Hospital of the University of Helsinki. Due to the retrospective post-operative nature of the study, no ethical approval was needed. Operated dogs with (case) and without (control) chronic GI signs following GDV surgery were selected based on a subsequent interview of the owners completed in spring 2011. All collected data was used as variables in modeling risk factors.

Data collection before and during surgery

Medical records between January 2004 and May 2008 were searched for dogs that underwent acute GDV surgery at the Veterinary Teaching Hospital. Dogs were included in the study if GDV was confirmed at surgery, incisional gastropexy was performed, and if the dogs were still alive at least 30 days postoperatively. All operated patients were treated according to a standard pre- and postoperative treatment protocol, which consisted of preoperative treatment with intravenous lactated Ringer's solution[i] boluses (20 ml/kg) along with colloid[ii] boluses (5–10 ml/kg), and when needed, with 7 % hypertonic sodium chloride[iii] solution (4 ml/kg). The pain was managed with levomethadone hydrochloride [iv] (0.3 mg/kg, slow intravenous administration), and preoperatively an antibiotic was administered intravenously (ampicillin[v] 22 mg/kg; or sulfadoxine with trimethoprim[vi] 15 mg/kg). Gastric decompression was achieved with percutaneous placement of a trocar into the gas-distended stomach. The incisional gastropexy technique described by Allen and April [17] was used in all surgeries. Although the surgery itself was performed by many different surgeons, it was always either carried out or supervised by a senior surgeon. Postoperatively, the patients were brought into the intensive care unit (ICU), where the crystalloid solution therapy was maintained, antibiotic therapy, if necessary, was continued and metoclopramide[vii] medication (0.3 mg/kg intravenously three times per day), if necessary, was started, to improve the intestinal motility. Postoperative pain was managed with opioids.

Footnotes

i Ringer-acetat, Fresenius Kabi, Halden, Norwegian.
ii Gelofusine, B. Braun Melsungen AG, Melsungen, Germany.
iii Natriumklorid Braun 234 mg/ml, B. Braun Melsungen AG, Melsungen, Germany.
iv L-polamivet, Intervet International GmbH, Unterschleissheim, Germany
v A-pen, Orion Pharma, Espoo, Finland.
vi Duoprim vet, Intervet Schering-Plough Animal Health, Boxmeer, Netherlands.
vii Primperan, Sanofi Winthrop Industrie, Quetigny, France.

Signalment, including age, sex, breed and weight, as well as pre-surgical clinical status such as body temperature, was obtained from patient records and used in modeling the risk factors. Due to the possible breed influence on the occurrence of chronic GI signs after surgery, breeds were divided into GDV predisposed and non-predisposed groups [1 -3]. The following data were also used in the models: laboratory data (hematocrit, leucocytes, protein, glucose, urea, creatinine, pH, and lactate), surgeon (junior or senior), splenectomy performed or not, GI foreign bodies, time of surgery (office hours or emergency duty time), antibiotic and metoclopramide treatment in the ICU, post-operative arrhythmias, and death closely related to the surgery.

Data collection after surger

Owners of the participating dogs were interviewed using a GI questionnaire developed by three researchers (PB, OLV and AHB). The interviews were conducted by telephone by one researcher (PB) and continued as a mailed questionnaire for the eight owners who were not reached by phone. The owners were asked about chronic GI signs, the type of diet the dogs received, the feeding frequency, speed of eating, appetite, eating from an elevated food bowl, and the resting time between exercises and feeding, both before and after surgery. The frequency of deworming before GDV surgery and the use of non-steroidal

anti-inflammatory drug (NSAID) medication and supplements such as calcium, fatty acids, and vitamins were also enquired.

Definitions of variables

GI signs were defined as chronic when vomiting, diarrhea, dilatation, borborygmus, abdominal pain, flatulence, or eructation, occurred continuously for three weeks or more either before or after GDV surgery, however excluding the time periods that might have been tied to surgery itself; three days before and three weeks after surgery. Dilatation was defined as the owner's subjective evaluation of a distended abdomen in the time frame of three weeks after surgery until the completion of the interviews. Pain was assessed as the owner's subjective evaluation of depression, restlessness, and vocalization.

The dogs were divided into two groups as follows: dogs having chronic GI signs after GDV surgery and dogs having no GI signs after GDV surgery. Both groups included dogs that either had or did not have had GI signs before surgery. Diet was divided into only commercial dry food, only homemade food (raw or cooked), commercial dry food mixed with homemade food, medical diets designed to manage gastrointestinal disorders (including both commercial GI dry foods and home cooked or raw GI diets), and any diet supplemented with table scraps. In this study we did not ask owners for any defined composition or amount of calories for table scraps given. Table scraps included left over from family meals; usually milk products, cereals, bread, cheese, ham and sausage from breakfast, and potato, rice or pasta with fish or meat and vegetables from dinner.

The following new variables were calculated from the electronic patient database: median time from onset of clinical signs to admission, median time in hospital, median time between surgery and the interview in months, and mortality data.

Statistical methods

Perioperative patient descriptives of dogs having or not having chronic GI signs after GDV surgery were compared and the statistical significance of differences between these groups was tested using appropriate statistical methods: the chi-squared test (likelihood ratio), Fisher's exact test, the independent-samples Kruskal-Wallis test and the independent-samples Mann-Whitney U-test.

Logistic regression was used to model the association of collected variables (before, during and after surgery) with two outcomes: the occurrence of GI signs and the occurrence of renewed dilatation after surgery.

The pairwise associations between the outcomes and each independent variable were studied using Fischer's exact test and crude logistic regressions (with only one independent variable in the model at a time). Non-correlating variables with Wald's $p < 0.2$ were included in multiple logistic regression analysis, dropped one by one, and variables with Wald's $p \leq 0.05$ were included in the final models.

Variables that did not reach a significance of $p < 0.2$ were not considered for modeling. Also, despite all having a Wald's $p < 0.2$, vomiting, flatulence, borborygmus, and pain after surgery were not included, since they were probably part of the GI signs leading up to a renewed dilatation. More than one variable that correlate significantly with each other cannot be included in the same regression model. Thereby, the clinically most relevant ones were kept in the "GI signs after surgery" model: "GI signs before surgery" (diarrhea, flatulence and vomiting before surgery omitted), "table scraps before surgery" (supplemented vegetables, dairy products and table scraps after surgery omitted), and "age" (hematocrit omitted). In the renewed dilatation model the following variables were kept:" dilatation before surgery" and "age" (body temperature and hematocrit omitted). Due to the large number of missing values, and the fact that most were within normal reference values, pre-surgical body temperature (n = 50) and leukocyte counts (n = 21) were not included in the analyses. Similarly, any GI diet after surgery, more frequent daily feeding, and a longer rest between eating and exercising were not included, as they are normal instructions given to the owner after a GDV event.

The impact of potential confounders such as GDV-predisposed breeds and the time between surgery and completion of the questionnaire was assessed by adding them to the models and observing their effect on the associations of interest; none were found. One-level interactions of independent variables in the final model were tested. They were not signifi-cant and not kept in the model. The goodness of fit of the final model was assessed with the Omnibus test of model coefficients, Nagelkerke's R2 and the Hosmer and Lemeshow test, and by calculating the area under the curve (AUC). The smaller the p-value in the Omnibus test and the larger in the Hosmer and Lemeshow test, and the closer the value to 100 % in Nagelkerke's R2 and the value of one in AUC, the better was the fit. Statistical analyses were performed using the statistical software SPSS 22.0 (IBM SPSS Statistical Package version 22, USA). The 95 % confidence intervals (CI) for percentages were calculated using the EpiTools asymptotic (Wald) method [18, 19].

Results

Between January 2004 and May 2008, 152 dogs were operated due to acute GDV signs. Forty-nine of them were omit-ted from the study due to the following reasons: 16 dogs had gastropexy as a prophylactic procedure, eight were euthanized during surgery, five died or were euthanized in the emergency unit soon after surgery, three were euthanized within 30 days after surgery, and the owners of 17 dogs could not be contacted after surgery. Therefore, 103 dogs were included in the study. From

these, information including dietary and exercise habits was available for 98 dogs.

Eight of the 103 dogs were euthanized later than 30 days after GDV surgery because of recurrent dilatation (six dogs), persistent diarrhea and weight loss (one dog), and dilatation with splenic torsion (one dog). The short-term mortality in this study was 11.8 % (95 % confidence interval (CI), 6-17 %) and the long-term mortality 7.8 % (95 % CI, 3-13 %), with a median follow-up time of 40 months (range 1-84 months). The overall mortality was 19.6 % (95 % CI, 11-24 %).

Occurrence of GI signs, descriptive data and feeding

Altogether, 54.4 % (56/103; 95 % CI, 45-64 %) of the dogs had chronic GI signs after surgery. Most of these dogs (40/56) had one or several GI signs both before and after surgery. Only 16 had GI signs only after surgery. Of the dogs that did not have any GI signs after surgery (45.6 %; 47/103), less than half (19/47) had had signs before surgery and the majority (28/47) had signs neither before nor after the GDV surgery (Table 1). Table 1 also presents the group distribution and median (range) of some descriptive data and some other variables of interest.

Table 1. Presurgical description of 103 GDV-operated dogs.

	GI signs after surgery, n = 56		No signs after surgery, n = 47		p-value
	GI signs both before and after surgery	GI signs only after surgery	GI signs only before surgery	No GI signs	Difference between groups
Number of patients (%; 95% CI)	40 (71.4; 59.6-83.3)	16 (28.6; 16.7-40.4)	19 (40.4; 26.4-54.5)	28 (59.6; 45.5-73.6)	NA
Sex: number of male (neutered)/female(spayed) (% for male; 95% CI)	26(5)/14(7) (46.4; 33.4-59.5)	14(3)/2(1) (25.0; 13.7-36.3)	13(4)/6(2) (27.7; 14.9-40.4)	14(1)/14(5) (29.8; 16.7-42.9)	0.092[a]
	40(8)/16(8) (71.4; 59.6-83.3)		27(5)/20(7) (57.4; 43.3-71.6)		0.152[b]
Breed: predisposed vs. non-predisposed (% for predisposed; 95% CI)	29 vs. 11	9 vs. 7	10 vs. 9	17 vs. 11	0.423[a]
	38 vs. 18 (67.9; 55.6-80.1)		27 vs. 20 (57; 43.3-71.6)		0.310[b]
Median age in years (range):	7 .0(1-13)	7.0 (1-12.5)	7.0 (2-13)	6.8 (1-12)	0.707[c]
	6.9 (1-13)		7.0 (1-13)		0.598[d]
Median body weight (kg):	41.1 (20- 82)	37.3 (18-75)	40.0 (10-70)	38.0 (26.5-70)	0.765[c]
	39.0 (17.7-82.0)		38.7 (10-70)		0.694[d]
Median time before admission in hours (range):	3.0 (1-72)	3.0 (1-48)	3 .0(1-12)	3.0 (1-36)	0.920[c]
	3.0 (1-72)		3.3 (1-36)		0.753[d]
Median time in hospital in hours (range):	20.0 (10-166)	18.5 (9-42)	23.0 (16-94)	20.0 (9-99)	0.446[c]
	19.8 (9-166)		20.5 (9-99)		0.720[d]

GDV = Gastric dilatation volvulus, GI = Gastrointestinal, [a] = Chi-squared Test/Likelihood ratio, [b] = Fisher's exact test, [c] = Independent-samples Kruskal-Wallis Test, [d] = Independent-samples Mann-Whitney U-test, NA = Not applicable.

Ninety-six percent (94/98; 95 % CI, 92-100 %) of the dogs were fed commercial dry food in some form before and 87.8 % (86/98; 95 % CI, 81-94 %) after GDV surgery. Normal dry food as the only diet accounted for 19.4 % (19/98; 95 % CI, 12-27 %) of the diets before and 17.3 % (17/98; 95 % CI, 10-25 %) of the diets after surgery, while a mixed diet of dry and home-cooked or raw food accounted for the rest. Medical diets were fed to 7.1 % (7/98; 95 % CI, 2-12 %) of the dogs before (all belonging to the group having GI signs before and after surgery) and to 31.6 % (31/98; 95 % CI, 22-41 %) after GDV surgery.

Home-prepared food as the only diet was only given to four dogs before surgery, and could not therefore be analyzed. However, table scraps were fed to 41.8 % (41/98; 95 % CI, 32-52 %) of dogs before and to 29.5 % (29/98; 95 % CI, 21-39%) of dogs after surgery. Forty-four percent of the 98 dogs had been given supplements before the surgery: 24.5 % received fatty acids, 13.3 % vitamins, 13.3 % joint supplements, and 2.0 % extra calcium.

Risk factors for chronic GI signs after surgery

Metoclopramide was started in 92.2 % (95/103; 95 % CI, 87-97 %) of the dogs, and its use was significantly (Fisher's exact p = 0.007) and negatively associated with GI signs after surgery. Antibiotic medication was started in 35.9 % (37/103; 95 % CI, 27-45 %) of the dogs in the ICU after GDV surgery. Continuous NSAID medication was given before GDV surgery to 7.1 % (7/98; 95 % CI, 2-12 %) of the GDV-operated dogs.

Altogether, 99.0 % (97/98; 95 % CI, 97-101 %) of the dogs had regularly been dewormed, 83.7 % (82/98; 95 % CI, 76-91 %) one to two times per year, and 10.2 % (10/98; 95 % CI, 4-16 %) three to four times per year. No GI foreign bodies were detected during surgeries.

The crude logistic regression results of statistically relevant potential risk factors associated with chronic GI signs after GDV surgery and some potentially confounding factors are presented in Table 2.

Table .2. Logistic regression analyses of potential risk factors for chronic GI signs after acute GDV surgery.

Risk factor (n_{tot}; $\%n_{GI}$ / $\%n_{No\ GI}$)		SEM	p-value	OR (95% CI)
Crude logistic regressions, p < 0.2				
Male vs. female (n = 103; 71% / 57%)	0.62	0.42	0.14	1.85 (0.82 to 4.20)
Predisposed breed vs. not (n = 103; 68% / 57%)	0.45	0.42	0.277	1.56 (0.70 to 3.50)
Age (years), (n = 103)	-0.04	0.06	0.537	0.96 (0.86 to 1.08)
Body weight (kg), (n = 99)	0.01	0.02	0.39	1.01 (0.98 to 1.04)
Body temperature (°C), (n = 50)	-0.44	0.33	0.177	0.64 (0.34 to 1.22)
Hematocrit (%), (n = 90)	0.04	0.03	0.092	1.05 (0.99 to 1.10)
Leukocytes (10^9/L), (n = 21)	0.76	0.34	0.023	2.15 (1.11 to 4.15)
GI signs before surgery vs. no (n = 103)	1.3	0.42	0.002	3.68 (1.62 to 8.38)
Diarrhea before surgery vs. no (n = 103; 41% / 17%)	1.22	0.47	0.01	3.40 (1.34 to 8.60)
Flatulence before surgery vs. no (n = 103; 36% / 19%)	0.85	0.47	0.066	2.35 (0.95 to 5.82)
Vomiting before surgery vs.no (n = 103; 23% / 13%)	-0.73	0.54	0.179	2.07 (0.72 to 5.95)
Table scraps before surgery vs. no (n = 98; 30% / 57%)	-1.12	0.43	0.009	0.33 (0.14 to 0.75)
Vegetables before surgery vs. no (n = 98; 43% / 21%)	1.01	0.46	0.029	2.75 (1.11 to 6.81)
Dairy products before surgery vs. no (n = 98; 39% / 24%)	0.73	0.45	0.109	2.07 (0.85 to 5.04)
Commercial GI diet after surgery vs. no (n = 98; 34% / 10%)	1.58	0.6	0.008	4.88 (1.52 to 15.71)
Table scraps after surgery vs. no (n = 98; 16% / 48%)	-1.56	0.48	0.001	0.21 (0.08 to 0.54)
Vegetables after surgery vs. no (n = 98; 29% / 12%)	1.08	0.56	0.053	2.96 (0.99 to 8.88)
More frequent daily feeding after surgery vs. less (n = 98)	0.73	0.28	0.009	2.08 (1.20 to 3.60)
Multiple logistic regression, final model (n), p < 0.05				
GI signs before surgery vs. no (n = 98)	1.16	0.45	0.01	3.20 (1.33 to 7.72)
Table scraps before surgery vs. no (n = 98; 30% / 57%)	-1.17	0.45	0.008	0.31 (0.13 to 0.74)
Constant	0.11	0.38	0.76	1.12 (NA)

n_{tot} = Number of dogs included in the analysis, $\%n_{GI}$ / $\%n_{NoGI}$ = Percentage that had the first mentioned trait (e.g. male, high age) in dogs that had GI signs after surgery compared to those that had no GI signs after surgery, B = Logistic regression coefficient, SEM = Standard error of the mean, p-value = Wald's p-value, OR = Odds ratio, CI = Confidence interval, NA = Not applicable.

GI signs before surgery and receiving table scraps before surgery were included in the preliminary multiple regression models together with sex, age, and predisposed breed, median time between surgery and interview, and hematocrit. The final model showed a statistically increased risk of suffering from chronic GI signs after GDV surgery when having had chronic GI signs before surgery (odds ratio (OR) 3.20, p=0.010), the signs mainly being flatulence, diarrhea, vomiting, and dilatation. Having received table scraps as part of their diet before surgery significantly decreased the risk (OR 0.31, p < 0.01) (Table 2).

Table 3. Logistic regression analyses of potential risk and associating factors for renewed dilatation after GDV surgery.

Risk factor (n_{tot}; $\%n_{RDil}$ / $\%n_{No\ RDil}$)	B	SEM	p-value	OR (95% CI)
Crude logistic regressions models, p < 0.2				
Duty vs. daytime surgery (n = 103; 83% / 96%)	-1.62	0.80	0.044	0.20 (0.04 to 0.95)
Age (years), (n = 103)	-0.15	0.08	0.040	0.86 (0.74 to 0.99)
Body temperature (°C), (n = 50)	-0.60	0.33	0.069	0.55 (0.29 to 1.05)
Hematocrit (%), (n = 90)	0.04	0.03	0.170	1.04 (0.98 to 1.11)
Dilatation before surgery vs. no (n = 103; 25% / 10%)	1.08	0.60	0.071	2.96 (0.91 to 9.61)
Table scraps before surgery vs. no (n = 98; 29% / 46%)	-0.72	0.51	0.152	0.48 (0.18 to 1.31)
Table scraps after surgery vs. no (n = 98; 12% / 35%)	-1.33	0.66	0.045	0.27 (0.07 to 0.97)
Antibiotic after surgery vs. no (n = 103; 54% / 30%)	1.00	0.48	0.037	2.71 (1.06 to 6.90)
Multiple logistic regression, final model (n), p < 0.05				
Table scraps after surgery vs. no (n = 98)	- 1.38	0.68	0.043	0.25 (0.07 to 0.96)
Age (years), (n = 103)	- 0.18	0.08	0.023	0.88 (0.71 to 0.98)
Constant	0.36	0.56	0.527	NA

n_{tot} = Number of dogs included in the analysis, $\%n_{RDil}$ / $\%n_{No\ RDil}$ = Percentage that had the first mentioned trait (e.g. male, high age) in dogs that had a renewed dilatation after surgery compared to those that did not have one, B = Lo-gistic regression coefficient, SEM = Standard error of the mean, p-value = Wald's p-value, OR = Odds ratio, CI = Con-fidence interval, NA = Not applicable.

Risk factors for renewed dilatation after GDV surgery

Forty three percent of the dogs with GI signs after surgery had renewed dilatation. All the same potential risk factors that were analyzed for the overall GI signs after surgery were again tested in crude regression analysis. Dogs that had been given antibiotics after surgery had an increased risk of renewed dilatation (crude OR 2.71, p = 0.037). However, this effect was not significant at the 5 % level after adjusting for other factors (pre-final OR 2.42, p = 0.084).

The final model associated dogs with increased age (OR 0.88, p=0.023) and dogs that had received table scraps as part of their diet after surgery (OR, 0.25, p=0.043) with a significantly decreased risk of renewed dilatation after GDV sur-gery (Table 3).

Discussion

The short-term (11.8 %), as well the long-term (7.8 %) and the overall (19.6 %) mortalities in our study were comparable with rates reported in earlier studies [2, 4-10], only one study by Glickman and others [1] have shown higher mor-tality rates (33.3%).

To our knowledge, no previously published studies have reported chronic GI signs after GDV surgery. Factors underlying non-specific GI signs are numerous and could include infections with parasites, pathogenic bacteria, intestinal dysbiosis, and/or adverse food reactions. There is only one previous study by Braun and others [20] which has raised the possibility of an association between pre-existing GI disease and GDV.

In their study, the correlation between GDV and pre-existing GI disease was evaluated in 23 dogs. Mid-jejunal full-thickness biopsies were collected at the time of GDV surgery and suggested a possible association between GDV and inflammatory bowel disease (IBD). However, the authors did not report whether the GI signs continued after the GDV surgery.

Non-specific GI signs have been described in association with intermittent gastric malposition in three studies [21-23]. Two other studies have reported GDV and mesenteric volvulus as rare complications of exocrine pancreatic insufficiency (EPI) [24, 25].

The literature includes several studies on risk factors for GDV per se, such as a predisposed breed, the pre-operative diet, and the consistency of the diet [1, 7, 11, 12, 14, 15] but possible risk factors for chronic GI signs after GDV surgery have to our knowledge not previously been published. The present study did reveal some pre-surgical factors associating with the development of chronic GI signs after surgery, two of which ended up in our final model (Table 2). These were chronic GI signs (diarrhea, vomiting, flatulence, or dilatation) before surgery, which increased the risk, and receiving table scraps before surgery, which decreased the risk of chronic GI signs after surgery.

In a case control study by Glickman and others [11], supplementing the usual diet, primarily consisting of dry dog food, with table scraps decreased the risk of GDV. This outcome supports our finding that receiving table scraps after surgery decreased the risk of not only GI signs, but also renewed dilatation after surgery. However, table scraps seem not only to be associated with a decreased risk of diseases; an increased risk of acute pancreatitis has also been reported [26].

The effect of ingredients in dry foods on the risk of GDV was investigated by Raghavan and others [15]. Their findings suggested that the feeding of dry dog foods that list oil or fat ingredients among the first four labeled ingredients predis-poses to a higher risk of GDV. This could not be checked in this study, as we had no information on the composition of the dry foods used by the owners. Gastric emptying in humans is known to be partially affected by the macronutrient composition of the food [27], whereby carbohydrates and proteins are emptied faster from the stomach than fats. Delayed gastric emptying in dogs may cause chronic gastric distension, leading to partial or complete volvulus of the stomach [28]. However, more studies are needed to investigate the effects of different food types on GDV development and the occurrence of chronic GI signs after GDV surgery.

We also found that older dogs had a lower risk of renewed dilatation after GDV surgery. This contradicts earlier studies [1, 6, 7, 13], in which increasing age has been associated with an increasing risk of GDV. The reason for this might be that older dogs have a higher risk of a first occurrence of GDV and younger dogs of a relapse. In addition, there was a statistically significant effect of postoperative antibiotic use in the crude logistic regression model; increasing the risk of renewed dilatation after surgery. Antibiotics are usually administered after surgery in more severe clinical cases requiring more intensive medical care. However, antibiotic treatment can also cause dysbiosis, possibly resulting in clinical GI disease. In human medicine, recent evidence has demonstrated that the dysbiotic impact of some antibiotics remains in the patient for an extended period of time, up to four years [29]. Future studies should again assess the possible causal connection between postsurgical antibiotic treatment and renewed dilatation.

Our finding of renewed dilatation in 23% of dogs after GDV surgery is comparable with an earlier study by Eggertsdóttir and others [30], in which gastric dilatation with or without volvulus was detected in 20 % (4/20) of the dogs after gastrocolopexy and in 9 % (2/22) after circumcostal gastropexy. In

another study by Meyer-Lindenberg and others [31], the rate of recurrence of gastric dilatation after gastropexy was 6.6 %. Renewed dilatation was defined in our study as the owner's subjective evaluation of a distended abdomen. Therefore, false interpretation and overestimation by untrained owners could be one explanation for the higher recurrence of dilatation in our study.

One interesting finding of the present study was that 29 % of dogs with chronic GI signs after GDV surgery only presented these signs after surgery. To our knowledge, no earlier studies have confirmed an association between chronic GI signs and surgical gastropexy techniques. Only one study has reported short- and long-term complications after endoscopically assisted gastropexy in dogs, in which two dogs vomited and four dogs had diarrhea within four weeks after surgery [32]. Vomiting resolved with famotidine administration and diarrhea without medical intervention.

In the current study, the surgery procedures were performed or supervised by senior surgeons. The large number of surgeons is explained by the fact that our institution is a teaching hospital. However, a standard incisional gastropexy technique was performed in all surgeries. It can, however, be speculated that the fixation angle of the stomach to the abdominal wall and individual differences in the anatomical structures of the dogs could cause postsurgical mechanical outflow obstruction and delayed gastric emptying. This might induce subsequent GI signs such as gastric distension, renewed dilatation and/or vomiting. Eggertsdóttir and others [30] compared the recurrence of gastric dilatation or GDV in dogs following the two previously mentioned gastropexy methods. They found that the operated dogs that showed no signs of abdominal pain or severe gastrointestinal problems did not have a recurrence of GDV either. However, no information on possible chronic GI signs before or after surgery was presented. Also, gastric foreign bodies have been detected during GDV surgery and are therefore significantly associated with GDV in dogs [16]. However, in the present study, no foreign bodies were detected.

This study had several limitations, one being its retrospective nature. Dogs included in the study were operated between January 2004 and May 2008, and the interviews with the owners were completed in spring 2011. The long time span might have made it difficult for the owners to remember exact details asked about in the questionnaire. Furthermore, the retrospective nature of this study did not allow assessment of the actual causal relationships between pre- and postsurgical GI problems, and it was also impossible to evaluate the role of preoperative shock on chronic GI signs after surgery. In our study, it was not possible to obtain more detailed information on most of the operated dogs, since the majority of them were referred emergency patients. Another limitation in our study is that this was an owner-based survey. Survey accuracy could have been influenced by how the owners' were able to interpret their dog's symptoms. The validity of the owner answers can be discussed, as the fact that dogs that suffered from GI signs before the GDV event might have prepared owners better for looking out for these types of signs also after the event. Also owners' character and the time spent daily with the dog might have had an effect on the accuracy of the given information. More accurate owners would maybe observe milder GI signs and give more exact information compared to inaccurate owners. Also owners spending more time with their dog might see more GI sigs compared to owners spending less time with their dog but the time the owner was spending with her/his dog was not asked in our questionnaire. However, in this study one single researcher was interviewing all owners, simultaneously filling in the questionnaire. Owners were interviewed about their dog's GI signs, eating habits etc. using the same interview structure, making sure that the owner had understood the question and that the answers were correct. Also, all questionnaires were answered in one go, and no owner were given any time to prepare for the interview. All these make the data more homogenous and therefore much stronger and avoid responder bias, at least to some extent. Furthermore, the large number of operating surgeons limits the possibility to evaluate the impact of a certain surgeon or a personal technique, on GI signs after surgery.

In conclusion, our study demonstrated that, according to owners' reports, around half of the dogs had chronic GI signs after GDV surgery. The risk of such signs appeared to be higher in dogs where owners reported chronic GI signs before surgery, but lower in those receiving table scraps before surgery. Also, receiving table scraps after surgery was associated with a lower risk of renewed dilatation after surgery. Conversely, older age appeared to decrease the risk of re-newed dilatation post-operatively. Due to the large proportion of dogs having chronic GI signs and renewed dilatation after GDV surgery in the present study, it seems justified to propose a postsurgical follow-up visit for further diagnostic work-up, especially in dogs that already suffered from chronic signs before the acute GDV event. The role of age and diet on chronic gastrointestinal signs after GDV surgery also warrants further studies.

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