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Retrospective Study

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Preoperative thoracic radiographic findings in dogs presenting for gastric dilatation-volvulus (2000–2010): 101 cases

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Abstract

Objective – To identify the incidence of clinically significant findings on preoperative thoracic radiographs in dogs with gastric dilatation-volvulus (GDV) and to determine if those findings are associated with survival.
Design – Retrospective study from 2000 to 2010.
Setting – Urban university small animal teaching hospital.
Animals – One hundred and one dogs diagnosed with GDV that had thoracic radiographs obtained preoperatively, and medical records available with the following information available: signalment, time of presentation, respiratory status, plasma lactate, presence of cardiac arrhythmias, reason for thoracic radiographs, radiographic findings, and outcome.
Interventions – None.
Results – Findings on preoperative thoracic radiographs included small vena cava (40%), esophageal dilation (39%), microcardia (34%), aspiration pneumonia (14%), cardiomegaly (5%), pulmonary nodule (4%), pulmonary edema (2%), sternal lymphadenopathy (1%), and pulmonary bullae (1%). Eighty-four percent of dogs (85 out of 101) survived to discharge. Dogs without cardiomegaly on presenting thoracic radiographs had a 10.2 greater odds of surviving to discharge.
Conclusions – The most common findings on preoperative thoracic radiographs include esophageal dilation, microcardia, and a small vena cava while the incidence of pulmonary nodules was low. A negative association between survival and presence of cardiomegaly on preoperative thoracic radiographs in dogs with GDV supports the need to obtain these images for prognostic information in spite of the emergency surgical nature of the GDV. The main limitations of this study include the possibilities of type I and type II errors, the retrospective nature of the study, and the lack of well-defined criteria for obtaining thoracic radiographs.

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Abbreviation

GDV gastric dilatation-volvulus

Introduction

Gastric dilatation-volvulus (GDV) is an acute life-threatening condition that typically occurs in large, deep-chested adult dogs. The disease is defined by an abnormal accumulation of gas and fluid in the stomach, extreme gastric distension, and rotation of the stomach on its longitudinal axis, resulting in subsequent cardiorespiratory dysfunction and shock.[1]

Mortality rates for dogs with GDV range from 10% to 43%.[2–7] Mortality has been previously associated with prolonged, inadequate tissue perfusion.[3,8,9] This is supported by experimental studies where longer periods of ischemia cause increased organ damage.[10–14] For this reason, immediate surgical intervention is recommended to reduce the chance of gastric and splenic injury, both of which have previously been correlated with prognosis.[5,7,15,16]

Standard preoperative diagnostics include hematology, serum biochemistry profiles, and a right lateral abdominal radiograph.[17] Preoperative medical

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treatment includes IV fluid therapy, analgesia, and gastric decompression.[2,3,18–20] As surgery should be performed as soon as the animal's condition has been stabilized, extraneous preoperative diagnostics may not be performed unless they will contribute useful prognostic information.[21]

There are several previously identified prognostic indicators that can be evaluated preoperatively. One measurement that should be done preoperatively is a plasma lactate concentration. In the de Papp et al[2] study, an initial plasma lactate concentration of < 6 mmol/L was associated with a better outcome.[2] In the Zacher et al[22] study, an initial lactate concentration of < 9.0 mmol/L and calculated changes in final lactate concentration in response to fluid therapy (final lactate ≤ 6.4 mmol/L, absolute change of > 4 mmol/L, or a percentage change in $> 42.5\%$) were associated with a better prognosis.[22] This response to treatment was also found to be a prognostic indicator in the Green et al[23] study where a declining plasma lactate concentration of $>50\%$ was associated with predicting survival.[23] An electrocardiogram also is recommended as cardiac arrhythmias were found to be associated with significantly increased mortality rates in some studies.[7,15,24]

A preoperative thoracic radiograph is not standard operating procedure for dogs with GDV in our institution. In most instances, the decision to acquire preoperative thoracic radiographs is at the discretion and preference of the clinician. Reasons for which a clinician may choose to acquire these images include screening for neoplasia, aspiration pneumonia, hypovolemia, esophageal abnormalities, and cardiac disease. However, with a disease process that requires immediate surgical intervention, additional time to acquire these images may not be justifiable. Other reasons the clinician may choose to not acquire these images include putting the animal at risk of regurgitation with ventrodorsal positioning and increased cost to the clients.

The objectives of the study here were (1) to identify the incidence of clinically significant findings on preoperative thoracic radiographs in dogs with GDV and (2) to determine if there is an association between the thoracic radiographic findings and survival, in order to determine the usefulness of acquiring these images. Our hypotheses were that (1) the overall incidence of abnormal thoracic radiographic findings would be low, and (2) despite an overall low incidence, preoperative acquisition of thoracic radiographs would provide prognostic information in certain circumstances and should be considered in the preoperative work up. No prior studies have examined the incidence of findings on thoracic radiographs on preoperative GDV cases.

Materials and Methods

Case selection

Medical records of dogs that presented for and diagnosed with GDV at an urban university small animal teaching hospital between 2000 and 2010 were reviewed. In all cases, the diagnosis of GDV was made from a right lateral abdominal radiograph. Dogs with preoperative 3 view standard thoracic radiographs were eligible for inclusion in the study.

Medical records

Data retrieved from the medical records of dogs included breed, age, sex, time of day of presentation to the hospital, respiratory status at presentation, plasma lactate pre-fluid resuscitation, plasma lactate post fluid resuscitation (if measured), preoperative cardiac arrhythmias, reason for performing thoracic radiographs as noted in the medical record, final radiology report from a board certified radiologist, preoperative decompression method, and outcome (survival to discharge). The presence or absence of the following findings on the thoracic radiographs was noted: esophageal dilation, microcardia, small cranial vena cava, neoplasia (diffuse metastatic disease, primary lung nodule, extrathoracic), aspiration pneumonia, pulmonary bullae, sternal lymphadenopathy, cardiomegaly, and pulmonary edema.

Statistical methods

Descriptive statistics were calculated. Based on non-normality of the data, continuous data were expressed as median values and ranges. Categorical data were expressed as frequencies. Logistic regression analysis was performed to evaluate risk factors for survival to discharge from the hospital. Risk factors evaluated included signalment (eg, sex, neuter status, breed, age); time of presentation (ie, 00:00–5:59, 6:00–11:59, 12:00–17:59, 18:00–23:59); presenting clinical signs (eg, panting, increased respiratory rate, increased respiratory effort, respiratory distress, ventricular arrhythmias, atrial arrhythmias); decompression (ie, none, orogastric tube, trocharization); plasma lactate at presentation; rationale for thoracic radiographs (ie, screening, respiratory disease suspected, heart disease suspected, to rule out metastatic disease); and thoracic radiographic findings (eg, microcardia, small vena cava, aspiration pneumonia, dilated esophagus, sternal lymphadenopathy, pulmonary bullae, pulmonary nodule, cardiomegaly, pulmonary edema). Univariate analysis was performed initially and factors with a Wald test P value < 0.20 were tested in the model. Interactions between the main effects were evaluated. Factors were retained in the model based on a Wald test P value < 0.05. Absence of confounding

was based on a factor changing model coefficients by < 15%. All analyses, including graphs to evaluate model assumptions, were performed with commercial statistical software.[a]

Results

Two hundred and thirty-four dogs were initially identified as presenting for and diagnosed with GDV during this time period. Of those dogs, 124 dogs had preoperative thoracic radiographs. Complete medical records were available for 101 of these cases and could be included in the study. The population consisted of 19 (19%) sexually intact males, 12 (12%) sexually intact females, 43 (42%) castrated males, and 27 (27%) spayed females. Breeds of dogs included mixed breed (14), German Shepherds (14 dogs), Great Danes (13), Standard Poodles (12), St. Bernard (8), Labrador Retriever (6), Basset Hound (4), Akita (3), Chow Chow (3), Rottweiler (3), Mastiff breeds (3), Doberman Pinschers (2), Golden Retrievers (2), Great Pyrenees (1), Husky (2), Weimeraner (2), German Short Haired Pointer (2), Boxer (1), Irish Setter (1), Chesapeake Bay Retriever (1), Greater Swiss Mountain Dog (1), Samoyed (1), English Springer Spaniel (1), and Rhodesian Ridgeback (1),

Thirty-nine percent of dogs presented between 18:00 and 23:59, 24% of dogs presented between 00:00 and 5:59, 22% of dogs presented between 6:00 and 11:59, and 15% presented between 12:00 and 17:59.

Thirty-two percent of dogs presented with panting, 27% presented with increased respiratory rate (>34 per minute), 20% presented with increased respiratory effort, and 2% presented with respiratory distress. At presentation, 6% were noted to have ventricular arrhythmias (eg, ventricular tachycardia and ventricular premature complexes), and 3% were noted to have atrial arrhythmias (eg, atrial premature complexes and atrial fibrillation).

Thirty-three percent of dogs were decompressed with an orogastric tube, and 26% were decompressed by trocharization. Forty-one percent of dogs in this population were not decompressed. Thirty-percent of dogs had a plasma lactate > 6.0 mmol/L, and 70% of dogs had a presenting plasma lactate < 6.0 mmol/L.

Eighty-four percent of radiographs were taken as a screening for metastatic disease prior to surgery, 10% of radiographs were taken for suspicion of respiratory disease, 6% were taken for suspicion of cardiac disease, and 1% of radiographs were taken to rule out metastatic disease when neoplasia was previously diagnosed. Suspicion of respiratory disease was based on the physical exam findings. Suspicion of cardiac disease was based on auscultation of a heart murmur, an audible arrhythmia, or previously documented abnormalities. The 1 dog that had thoracic radiographs taken to rule out metastatic disease due to the previous diagnosis of neoplasia had appendicular osteosarcoma treated with amputation and chemotherapy.

Table 1: Incidence of findings on preoperative thoracic radiographs in population of 101 dogs presenting with gastric dilatation and volvulus

Radiographic finding	Percent of dogs with finding (total no. of dogs)
Small caudal vena cava	40 (40)
Esophageal dilation	39 (39)
Microcardia	34 (34)
Aspiration pneumonia	14 (14)
Cardiomegaly	5 (5)
Pulmonary nodule	4 (4)
Pulmonary edema	2 (2)
Pulmonary bullae	1 (1)
Sternal lymphadenopathy	1 (1)

The findings on preoperative thoracic radiographs included small vena cava (40%), esophageal dilation (39%), microcardia (34%), aspiration pneumonia (14%), cardiomegaly (5%), pulmonary nodule (4%), pulmonary edema (2%), sternal lymphadenopathy (1%), and pulmonary bullae (1%) (Table 1).

Eighty-four percent of dogs (85 out of 101) survived to discharge. Sixteen percent of dogs (16 out of 101) died prior to discharge from the hospital. Of the nonsurviving dogs, 12/16 (75%) were euthanized due to poor prognosis, 2/16 (12.5%) dogs were euthanized due to financial constraints, and 2/16 (12.5%) dogs died during the postoperative recovery. Presenting characteristics and thoracic radiographic findings for these 2 groups of dogs are presented in Table 2.

There were 2 variables with a statistically significant association with survival to discharge from the hospital (Table 3). Controlling for presenting lactate concentration, dogs without cardiomegaly on presenting thoracic radiographs had a 10.2 greater odds of surviving to discharge compared to dogs with cardiomegaly identified. Controlling for the presence of cardiomegaly on thoracic radiographs, dogs with a plasma lactate < 6 mmol/L at presentation had a 7.3 greater of odds of surviving to discharge compared to dogs with a plasma lactate ≥ 6 mmol/L.

Discussion

The goal of this study was to identify the incidence of clinically significant findings on preoperative thoracic radiographs in dogs with GDV and to determine the usefulness of acquiring these images. Results documented the incidence of significant findings in thoracic radiographs and also indicated that evidence of cardiomegaly on preoperative thoracic radiographs was significantly

Table 2: Characteristics stratified by discharge from the hospital

	Did not survive to discharge from the hospital ($n = 16$)		Survived to discharge from the hospital ($n = 85$)	
Age (years)	**Median 10.3 range 4.6–15.0**		**Median 9.1 range 1.5–14.7**	
Breed	German Shepherd	2 (13%)	German Shepherd	12 (14%)
	Great Dane	3 (19%)	Great Dane	10 (12%)
	Mixed breeds	0 (0%)	Mixed breeds	14 (16%)
	Standard Poodle	1 (6%)	Standard Poodle	11 (13%)
	Other purebred	10 (62%)	Other purebred	38 (45%)
Sex and neuter status	Female spayed	3 (19%)	Female spayed	24 (28%)
	Female intact	2 (13%)	Female intact	10 (12%)
	Male castrated	7 (44%)	Male castrated	36 (42%)
	Male intact	4 (25%)	Male intact	15 (18%)
Time of presentation	0:00–5:59	3 (19%)	0:00–5:59	21 (25%)
	6:00–11:59	7 (44%)	6:00–11:59	15 (18%)
	12:00–17:59	0 (0%)	12:00–17:59	16 (19%)
	18:00–23:59	6 (38%)	18:00–23:59	33 (39%)
Presenting signs	Panting	2 (13%)	Panting	31 (36%)
	Increased resp rate*	7/15 (47%)	Increased resp rate*	21/84 (25%)
	Increased resp effort*	3/15 (20%)	Increased resp effort*	18 (21%)
	Respiratory distress	1 (6%)	Respiratory distress	43 (1%)
	Ventricular arrhythmias	2 (13%)	Ventricular arrhythmias	4 (5%)
	Atrial arrhythmias	1 (6%)	Atrial arrhythmias	2 (2%)
Decompression	Orogastric tube	4 (25%)	Orogastric tube	30 (35%)
	Trocharization	7 (44%)	Trocharization	20 (24%)
Lactate $\geq$6 mmol/L at presentation	10 (63%)		21 (25%)	
Rationale for thoracic radiographs	Screening	11 (69%)	Screening	73 (86%)
	Respiratory disease suspected	3 (19%)	Respiratory disease suspected	7 (8%)
	Heart disease suspected	2 (13%)	Heart disease suspected	4 (5%)
	Rule-out metastatic disease	0 (0%)	Rule-out metastatic disease	1 (1%)
Thoracic radiographic findings	Microcardia	7 (44%)	Microcardia	27 (32%)
	Small vena cava	8 (50%)	Small vena cava	32 (38%)
	Aspiration pneumonia	3 (19%)	Aspiration pneumonia	11 (13%)
	Dilated esophagus	9 (56%)	Dilated esophagus	30 (35%)
	Sternal lymphadenopathy	1 (6%)	Sternal lymphadenopathy	0 (0%)
	Pulmonary bullae	0 (0%)	Pulmonary bullae	1 (1%)
	Pulmonary nodule	0 (0%)	Pulmonary nodule	4 (5%)
	Cardiomegaly	2 (13%)	Cardiomegaly	3 (4%)
	Pulmonary edema	1 (6%)	Pulmonary edema	1 (1%)

*Not reported in 1 case.

associated with a decreased survival. This suggests that acquisition of thoracic radiographs may be warranted in the routine preoperative work up. In one study, the time from presentation to surgery was inversely associated with the overall mortality rate.[7] This does not advocate intentionally delaying surgery, but it does suggest that diagnostics deemed necessary, such as thoracic radiographs, may be performed in appropriate cases.

Sex, age, and breed distributions of dogs in the present study were similar to distributions for dogs in previous studies.[5,6] The reasons for chest radiographs were screening (83%), suspicion of respiratory disease (10%), to evaluate for underlying heart disease (6%), and for metastatic check in a dog with appendicular osteosarcoma (1%). In the majority of cases, the radiographs were taken as a screening for underlying pathology prior to surgery rather than due to the suspicion of disease.

Table 3: Risk factors for survival to discharge from the hospital

Variable	Odds ratio	*z*	*P*-value	95% CI
No cardiomegaly on thoracic radiographs	10.2	2.21	0.027	1.3–79.4
Lactate <6 mmol/L at presentation	7.3	3.08	0.002	2.1–25.6

The findings on thoracic radiographs included small caudal vena cava size (40%), esophageal dilation (39%),

microcardia (34%), aspiration pneumonia (14%), cardiomegaly (5%), pulmonary nodule (4%), pulmonary edema (2%), sternal lymphadenopathy (1%), and pulmonary bullae (1%). Microcardia and small caudal vena cava size were common findings likely due to the consequences of shock. Esophageal dilation was also common which occurs due to the mechanical obstruction from the gaseous distended stomach.[25] Interestingly, the most common reason for thoracic radiographs was screening of unsuspected underlying disease yet the presence of incidental findings were generally low, such as pulmonary nodules present in only 4% of cases.

Consistent with previous reports, presenting lactate was a prognostic indicator of survival.[2,22] Specifically, within the total population of dogs, dogs with a plasma lactate < 6 mmol/L had a 7.3 times the odds of survival to discharge compared to dogs that had a plasma lactate > 6 mmol/L at presentation.

Independent of plasma lactate, dogs with GDV that had evidence of cardiomegaly on their preoperative thoracic radiographs were found to have a decreased survival. Evaluation of the size and shape of the cardiac silhouette is routinely performed when reviewing thoracic radiographs. Cardiomegaly is enlargement of the cardiac silhouette and is primarily caused by enlargement of the ventricles. This finding is not specific and can signify different cardiac diseases including ventricular septal defect, cardiomyopathies, left-sided heart failure, chronic mitral, or tricuspid insufficiency. Other differentials for cardiomegaly include pericardial effusion and pericardial-peritoneal diaphragmatic hernia. Furthermore, interpretation of the heart size can be difficult due to confounding variables such as breed variation, obesity, and positioning.[26] The vertebral heart score is a method used for objectively evaluating the dimensions of the cardiac silhouette. Using this method, the cardiac long and short axes are measured on the lateral thoracic view and are then compared with the thoracic spine. The vertebral heart score is the sum of the long and short axes, each measured caudally from the cranial edge of the 4th thoracic vertebra. Normal vertebral heart score values have been established for different canine breeds and is typically between 8.7 to 10.7.[27]

The significance of the association between cardiomegaly on preoperative thoracic radiographs and poor survival is unknown. There are several explanations for why these dogs may have a decreased survival despite appropriate monitoring and treatment. As discussed, cardiomegaly can represent underlying cardiac disease, and anesthesia may have a higher risk. Even dogs with nonclinical heart disease may decompensate with the acute strain of anesthesia.[26] As discussed earlier, GDV patients require aggressive fluid therapy due to poor perfusion associated with their cardiovascular status.[19] In patients with underlying cardiac disease, there is a risk of excessive extracellular volume expansion and edema while receiving fluid therapy.[28]

In addition to volume overload and anesthesia, underlying heart disease may be exacerbated by other factors as well. Myocardial injury is well known to be associated with GDV.[21,22,26] Myocardial ischemia secondary to hypoperfusion, reperfusion injury, and oxygen-free radical production is thought to occur.[20,21,29–31] This has been supported by showing an increase in cardiac troponins in GDV patients.[32] These insults to the myocardium during the disease process may be exacerbating nonclinical underlying heart disease, making it difficult for the patient to compensate.

Similar to findings by Brockman et al,[5] while cardiomegaly was associated with poor outcome in our study group, cardiac arrhythmia was not a prognostic indicator.[5] This is in contrast to other studies where cardiac arrhythmias were found to be associated with a poor outcome and could potentially signify underlying heart disease.[7,15,24] It should also be noted that cardiac disease might be underestimated in the present study since a large percentage of dogs (33%) were identified to have microcardia secondary to hypovolemia. Therefore, a heart which may be enlarged under normovolemic conditions may appear small to normal in this study group.

The main limitations of the present study include the possibilities of type I and type II errors, the retrospective nature of the study, and the lack of well-defined criteria for obtaining thoracic radiographs. While a statistically significant finding, there were relatively few dogs that had cardiomegaly present on their thoracic radiographs. As is always the case, it is possible, based on the standard P value < 0.05, that this statistically significant negative relationship between cardiomegaly and survival to discharge could be attributed to a type I error. To further evaluate the relationship, a future study using a larger data set including many dogs with cardiomegaly could be performed. Complete medical records were not available for all patients with preoperative thoracic radiographs, which excluded some patients from the study. Due to incomplete records, it was also not possible to collect all the data of interest and therefore identify risk associated with it. For instance, final plasma lactate concentration following fluid resuscitation was not measured in many cases. The population of patients receiving thoracic radiographs was not standardized over this time period, which could have affected the results. There was no documentation as to why in some cases thoracic radiographs were not

performed. As the radiographs are performed at the request of either the emergency clinician or surgeon, there may be bias due to the different clinicians involved over the long study period. The argument could be made that in more sick patients, thoracic radiographs are not performed due to the concern for immediate surgery. A prospective study in which all patients receive radiographs would be indicated to remove this bias.

Analysis of the data from all dogs with GDV admitted to our veterinary hospital that met the inclusion criteria documented the incidence of findings on preoperative chest radiographs. To our knowledge, this has not been documented previously, and this is the first report of the incidence of findings on preoperative thoracic radiographs in dogs with GDV. The data also revealed that there was a negative association between survival and presence of cardiomegaly on preoperative thoracic radiographs. Preoperative thoracic radiographs, aside from screening for other underlying diseases as previously mentioned, may be performed to gain this prognostic information. Future studies evaluating cardiac function in dogs that had preoperative evidence of cardiomegaly on thoracic radiographs are warranted to truly define the relationship.

Footnote

[a] Stata version 11, StataCorp, College Station, TX.

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