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Mortality rates of dogs with acute gastric dilatation-volvulus syndrome presented at the University of Veterinary Medicine Vienna 2006–2011

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Summary

The objective of the current study was to determine the mortality rate of patients presented with acute gastric dilatation-volvulus (GDV) at the Vetmeduni Vienna. Information on signalment, duration of hospitalisation, success of therapy (discharge or death), duration of anaesthesia and surgery, overall mortality rate, overall postoperative mortality rate, and postoperative mortality rate among dogs that underwent different surgical procedures was collected for 152 dogs with GDV, 115 of which underwent surgical treatment. Great Danes were among the most commonly affected dogs and exhibited a significantly higher risk of developing GDV than did the general hospital population. Intact male dogs constituted the majority of affected dogs by sex. The mean duration of anaesthesia and surgery showed no significant difference between survivors and dogs that died postoperatively. Of the 110 dogs that underwent surgery and recovered successfully from anaesthesia, eight (7.27%) received partial gastrectomy. The overall mortality rate was 13.91%, and the overall postoperative mortality rate was 10%.

Zusammenfassung

Mortalitätsrate bei Hunden mit akutem Magendilatations-Volvulus-Syndrom an der Veterinärmedizinischen Universität Wien 2006–2011

Einleitung

Magenwandnekrosen im Zuge eines Magendilatations-Volvulus-Syndroms (MDV) und nachfolgende, partielle Resektionen der Magenwand wurden in aktuellen Publikationen bei 12–25% der Patienten durchgeführt. Die Mortalitätsraten wurden mit 10–25% angegeben. Das Ziel dieser Studie war es, die Sterberate bei Patienten mit MDV an der Veterinärmedizinischen Universität Wien zu bestimmen. Die Hypothese der vorliegenden Arbeit war, dass die Sterberate der Patienten mit MDV, die an der Veterinärmedizinischen Universität Wien behandelt wurden, gleich oder besser als in aktuellen Publikationen angegeben ist.

Material und Methode

152 Patienten mit MDV wurden im Beobachtungszeitraum an der Kleintierklinik der Veterinärmedizinischen Universität Wien vorgestellt. Von diesen wurden 115 einer chirurgischen Behandlung unterzogen. Nationale, Dauer des stationären Aufenthalts, Behandlungserfolg, Dauer der Anästhesie, Dauer bzw. Art der Chirurgie, Gesamtmortalität, postoperative Mortalität und postoperative Mortalitätsrate innerhalb der unterschiedlichen Operationsgruppen wurden ausgewertet. Die Intraoperative- und Gesamtmortalitätsrate sowie die Anzahl der durchgeführten Magenwandresektionen nach Magenwandnekrose wurden mit jenen von vorhergegangenen Studien im Rahmen eines statistischen Vergleichs ausgewertet.

Ergebnisse

Deutsche Doggen waren unter den am häufigsten von MDV betroffenen Hunden und zeigten im direkten Vergleich zur allgemeinen Patientenpopulation ein signifikant höheres Risiko an MDV zu erkranken. Hinsichtlich der Geschlechtsverteilung stellten männliche, unkastrierte Rüden den Großteil der betroffenen Patienten dar. Die durchschnittliche Anästhesiedauer von überlebenden bzw. postoperativ verstorbenen Patienten zeigte keinen signifikanten Unterschied. Von 110 Patienten, die einer

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In comparison with previous studies, this study shows a lower frequency of partial gastrectomies without a negative effect on treatment outcome. Although there might be various reasons for this lower frequency of gastric necrosis in the dogs from our study, a previous over interpretation of stomach wall necrosis in dogs with GDV can be presumed.

Operation unterzogen wurden und überlebten, erhielten acht (7,27%) eine Teilresektion der Magenwand. Die Gesamtmortalität betrug 13,91% und die postoperative Mortalitätsrate betrug 10%. Im Vergleich zu vorhergegangenen Studien konnte, bei vergleichbaren intra- bzw. postoperativen Mortalitätsraten eine niedrigere Magenwandresektionsrate festgestellt werden.

Schlussfolgerung
Die vorliegende Studie zeigt eine, im Vergleich zu vorangegangenen Studien, geringere Rate von Teilresektionen der Magenwand im Zusammenhang mit Magenwandnekrosen nach MDV ohne negative Beeinflussung des Behandlungserfolges. Obwohl die geringere Rate der Magenwandnekrosen in dieser Studie auch durch andere Parameter beeinflusst worden sein könnte, deuten die Ergebnisse auf eine, möglicherweise gängige Fehleinschätzung der Vitalität der Magenwand nach MDV hin.

Introduction

Gastric dilatation-volvulus (GDV) is a life-threatening condition caused by air accumulation within the stomach with a subsequent increased intra-luminal pressure and a rotation of the stomach. Various degrees of gastric malposition may result. Dilatation and rotation of the stomach influences the overall cardiovascular function (WINGFIELD et al., 1974; MUIR, 1982; SUGA et al., 1982; ORTON and MUIR, 1983a; VAN SLUIJS and HARPÈ, 1985: HALL, 1989; BECK et al., 2006), affects kidney function (HALL, 1989; MONNET, 2003), stimulates catecholamine release (ORTON and MUIR, 1983b; MONNET, 2003), and compresses the diaphragm with resultant impaired ventilation. Altered arterial oxygen content and delivery ensue (WINGFIELD et al., 1974, 1975a). Increased gastric pressure results in local ischemia and necrosis of the gastric mucosa. If this increased pressure is maintained, the muscularis and serosa can also be affected (HALL, 1989; MONNET, 2003; BECK et al., 2006). Additionally, breakdown of the gastrointestinal mucosa may lead to bacterial translocation and endotoxaemia (HAGLUND, 1993; MONNET, 2003). In this situation, reactive oxygen products interact with cells; damage proteins, DNA, and RNA; and induce membrane lipid peroxidation (BUBER et al., 2007). If not acutely treated, these processes will result in multiple organ failure and death (HALL, 1989; MONNET, 2003).

The treatment of GDV involves resuscitation and surgery (BETTS et al., 1974; LEIB and BLASS, 1984; ELLISON, 1993; MEYER-LINDENBERG et al., 1993; HOSGOOD, 1994; BROURMAN et al., 1996; BECK et al., 2006). With adequate stabilisation and subsequent surgery, the survival rate ranges from 82 to 90% (BROCKMAN et al., 1995; BROURMAN et al., 1996; BECK et al., 2006; MACKENZIE et al., 2010; BEER et al., 2013). However in presence of splenic injury or gastric necrosis, even if treated by additional surgical procedures such as gastrectomy and/or splenectomy, the postoperative mortality rate ranges from 15 to 68% (WINGFIELD et al., 1975b; BROCKMAN et al., 1995; BROURMAN et al., 1996; BROOME and WALSH, 2003; MACKENZIE et al., 2010). Gastrectomy due to gastric wall necrosis has been performed in 12–25% of GDV patients in previous studies (BROCKMAN et al., 1995; BROURMAN et al., 1996; MACKENZIE et al., 2010; ZACHER et al., 2010; GREEN et al., 2011; BEER et al., 2013). Since gastric wall vitality can only be assessed subjectively by the surgeon, an over interpretation – to avoid postoperative gastric wall necrosis and subsequent gastric wall rupture – is conceivable.

The aim of this retrospective study was to determine the mortality rate of acute GDV among canine patients presented to the University of Veterinary Medicine, Vienna, from 2006 to 2011. Our hypothesis was that our mortality rates do not differ significantly from the ones published in recent publications.

Materials and Methods

Materials

The medical records of canine patients presented to the Clinic for Small Animal Surgery, Department of Small Animals and Horses, University of Veterinary Medicine, Vienna, with a radiologic and surgical diagnosis of GDV from January 2006 to April 2011 were reviewed and statistically analysed. The obtained data of intra- respectively overall mortality rates and the partial gastrectomy rates was compared to data of recent (1995–2013) publications on GDV (BROCKMAN et al., 1995; BROURMAN et al., 1996; MACKENZIE et al., 2010; ZACHER et al., 2010; GREEN et al., 2011; BEER et al., 2013).

Patients

All patients presented with suspected GDV underwent initial decompression by gastrocentesis, cardiovascular stabilisation and fluid resuscitation, further decompression with a nasogastric tube if possible, abdominal radiography in right lateral recumbency, and surgical treatment after restoration of vital parameters.

Tab. 1: Breed distribution of dogs with gastric dilatation-volvulus presented at the University of Veterinary Medicine Vienna 2006–2011 and comparison with reference hospital population of same time period/Rasseverteilung der Hunde mit akutem Magendilatations-Volvulus-Syndrom vorgestellt an der Veterinärmedizinischen Universität Wien 2006–2011 im Vergleich zu allen in diesem Zeitraum vorgestellten Hunden

Breed	Quantity	%	Hospital population	CI* (low lim)	CI* (up lim)
Mixed	24	15.79			
German Shepherd	23	15.13	1000	0.0140	0.0323
Doberman Pinscher	15	9.87	242	0.0316	0.0920
Great Dane	13	8.55	161	0.0390	0.1230
Bernese Mountain dog	12	7.89	315	0.0170	0.0070
Irish Setter	6	3.95	139	0.0090	0.0770
Others (39 remaining breeds with ≤4 dogs/breed)	59	38.81			

*CI, confidence interval; low lim, lower limit; up lim, upper limit

Abdominal exploration was performed, and the stomach was derotated. Gastrotomy was not routinely performed. Gastric walls were evaluated for abnormalities, like loss of thickness and grade of discoloration, and treated by hand-sewn partial gastrectomy when stomach wall necrosis was suspected. Gastric invagination was not performed. In cases involving local necrosis of the spleen, major vascular avulsion, thrombosis, or torsion, partial or total splenectomy was performed. All patients underwent right-sided incisional gastropexy according to the technique described by MCCOY et al. (1982). Intraoperative monitoring included electrocardiography (ECG), body temperature, blood pressure, oxygen saturation, end-tidal carbon dioxide, and respiratory rate. Upon completion of surgery, all patients underwent nasogastric tube placement and recovery in the intensive care unit, where further stabilisation was provided. ECG monitoring and determination of the blood cell count, blood chemistry parameters, and blood gas levels were performed. In the absence of abnormal cardiac findings and after normalisation of vascular parameters, the patients were returned to the surgical ward and released two to three days postoperatively.

Data collection and analysis

The following data were collected and analysed:
Epidemiologic data
- Breed, sex, weight, and age

Clinical data
- Duration of hospitalization, defined as the period of time from presentation to discharge
- Survival rate, defined as the percentage of dogs that were successfully discharged from the hospital
- Overall mortality rate, defined as the percentage of dogs that died or were euthanized, either intraoperatively or postoperatively
- Postoperative mortality rate, defined as the percentage of dogs that died or were euthanized during the postoperative period (time from end of anaesthesia to hospital discharge)

Anaesthetic data
- Duration of anaesthesia, defined as the period of time from premedication to cessation of inhalation narcosis
- Mean heart rate, blood pressure, oxygen saturation, end-tidal carbon dioxide, respiratory rate, and body temperature
- Anaesthetic complications

Surgical data
- Duration of surgery, defined as the period of time from first incision to end of wound closure
- Surgical procedures (gastropexy, partial gastrectomy, partial or total splenectomy, or a combination of these procedures)
- Intraoperative pathological findings (gastric wall necrosis, vessel rupture, thrombosis, or others)

The following data were analysed with respect to mortality:
Duration of anaesthesia and surgery
- Duration of anaesthesia and surgery (range and mean ± standard deviation [SD]). A t-test with Welch correction was used to calculate statistically significant differences in independent samples.

Gastropexy, gastrectomy, partial or total splenectomy, or combination
- Absolute numbers and percentages were determined. The intraoperative respectively overall mortality and partial gastrectomy rates were compared with those of previous studies using a two-tailed Fisher's exact test (GStat 2.2, 2014).

Tab. 2: Sex distribution of dogs with gastric dilatation-volvulus presented at the University of Veterinary Medicine Vienna 2006–2011/Geschlecht der Hunde mit akutem Magendilatations-Volvulus-Syndrom vorgestellt an der Veterinärmedizinischen Universität Wien 2006–2011

Sex	Quantity	%
Male	62	40.79
Neutered male	27	17.76
Female	31	20.39
Neutered female	29	19.08
Unknown	3	1.97

Tab. 3: Overview and comparison of overall mortality, postoperative mortality and percentage of partial gastrectomy in dogs with gastric dilatation-volvulus/Übersicht und Vergleich der Gesamtmortalität, der intraoperativen Mortalität und des Anteils an partiellen Gastrotomien bei Hunden mit akutem Magendilatations-Volvulus-Syndrom

Study	number of dogs	Overall mortality in% (n)	p 1*	Intraoperative mortality in% (n)	p 2*	partial gastrectomy rate in% (n)	p 3*
Current Study	115	13.9% (16)		4.3% (5)		7.21% (8)	
ZACHER et al. (2010)	64	23.4% (15)	0.16	12.5% (8)	0.08	25% (14)	0.003
GREEN et al. (2011)	84	12% (10)	0.84	11.9% (10)	0.08	12.2% (9)	0.39
MACKENZIE et al. (2010)	306	9.8% (30)	0.30	3.9% (12)	0.93	19.7% (58)	0.004
BEER et al. (2013)	73	11% (8)	0.71	4.1% (3)	0.77	17.1% (12)	0.07
BROCKMAN et al. (1995)	193	15% (29)	0.92	5.7% (11)	0.8	14.2% (26)	0.10
BROURMAN et al. (1996)	137	17.5% (24)	0.54	3.6% (5)	0.96	17.4% (23)	0.03

*p 1 = difference to current study in overall mortality; *p 2 = difference to current study in intraoperative mortality; *p 3 = difference to current study in partial gastrectomy rates

P<0.05 was considered to be statistically significant.

Preoperative and postoperative ECG changes

Absolute numbers and percentages were determined. Analyses were performed with a statistical software package (IBM SPSS Statistics for Windows, Version 19.0; Armonk, NY, USA) and Microsoft Excel (Microsoft, Redmond, WA, USA). Quantities are reported as absolute numbers and percentages. Variables are reported as mean±SD when normally distributed. Differences were considered significant at p<0.05 using the t-test. Independent samples were analysed with Welch correction with 95% confidence intervals.

Results

Epidemiological data

One hundred fifty-two dogs were presented and treated for acute GDV from January 2006 to April 2011. The breed distribution of this population is shown in Table 1.

Dogs in the reference hospital population that presented with an episode of GDV during the same time period comprised 2.3% (23/1000) of the German Shepherd dogs, 6.19% (15/242) of the Doberman Pinschers, 8.07% (13/161) of the Great Danes, 3.80% (12/315) of the Bernese Mountain Dogs, and 4.31% (6/139) of the Irish setters. Comparison of these breeds showed that Great Danes had a significantly higher risk of developing GDV than did other breeds (CI: 0.039; 0.123).

The sex distribution of the 152 dogs is shown in Table 2. The majority of dogs presented with GDV were intact male dogs (40.79%).

The age and body mass of the patients ranged from 1.19 to 15.82 years (mean 8.42±3.13 years) and 12.30 to 94.80 kg (mean 40.46±13.98 kg), respectively.

Clinical data

In total, 152 dogs with GDV were presented during the study period. Thirty-seven were euthanized preoperatively at the owners' request for different reasons (financial reasons, poor prognosis…). The remaining 115 dogs underwent surgical treatment. Sixteen of these 115 dogs (13.91%) died or were euthanized intraoperatively (n=5) or postoperatively (n=11). Of the five dogs that died intraoperatively, four where euthanized at the owners' wish because of the intraoperative findings and poor prognosis, and one died. The remaining 99 of the 115 dogs (86.09%) were successfully treated and discharged from the hospital.

Of the 110 dogs that survived the surgical procedure and recovered from anaesthesia 94 (85%) underwent only right-sided gastropexy. Nine (10%) of these dogs died postoperatively and 85 (90%) where successfully discharged.

Sixteen (13.91%) of the 110 dogs underwent one or several additional surgical procedures in combination with gastropexy. In eight of 110 (7.27%) dogs, total (n=7) or partial (n=1) splenectomy was performed. Of these dogs only one died during the postoperative period. Three (2.72%) dogs received solely partial gastrectomy in addition to gastropexy. All of these three dogs were successfully discharged from the hospital. A combination of gastropexy, partial or total splenectomy and partial gastrectomy was performed in five (4.54%) of the 110 patients. One of these dogs died during the postoperative period. The overall partial gastrectomy rate was therefore eight of 110 dogs (7.27%).

The overall mortality rate, including intraoperative (both euthanasia and other deaths) and postoperative

deaths, was 13.91% (16 of 115 dogs). The postoperative mortality rate was 10% (eleven of 110 dogs).

When comparing the intraoperative and overall mortality rate with those of previously conducted studies, no significant difference could be discovered. Although the percentage of partial gastrectomies was the lowest in our study (7.27%) when compared to percentage (12–25%) reported elsewhere (BROCKMAN et al., 1995; BROURMAN et al., 1996; MACKENZIE et al., 2010; ZACHER et al., 2010; GREEN et al., 2011; BEER et al., 2013), the difference was statistically significant only when compared to the results of BROURMAN et al. (1996), MACKENZIE et al. (2010) and ZACHER et al. (2010) (Tab. 3).

The mean duration of anaesthesia and surgery was 133.99±44.39 (range, 60–300) and 99.88±33.71 (40–195) min, respectively, among survivors and 144.09±28.30 (range, 120–195) and 106.50±16.02 (range, 85–145) min, respectively, among dogs that died postoperatively. There was no significant difference between the duration of anaesthesia (p=0.197) or surgery (p=0.177) between the two groups.

Preoperative and postoperative premature ventricular contractions were observed in nine (7.82%) and 54 (49.09%) of the 115 dogs, respectively.

Discussion

In total, 152 dogs were presented and treated for acute GDV during the study period. The majority of affected breeds were large mixed-breed dogs (24/152, 15.79%) and German shepherd dogs (23/152, 15.13%). These results are consistent with those reported in a previous study by BECK et al. (2006), who found that 22/166 (13.3%) mixed-breed dogs and 23/166 (13.9%) German shepherd dogs were affected by GDV. GLICKMAN et al. (2000b) reported that large- and giant-breed dogs have a 24% lifetime risk of developing GDV, respectively, while the Great Dane has a lifetime risk of 42% (GLICKMAN et al. 2000a). In the present study, Great Danes were also found to have a significantly higher risk of developing GDV. Our findings are also consistent with a large internet-based survey study which revealed the highest risk for GDV in German shepherd dogs (301/1114, 12%) and Great Danes (281/1114, 11%) (PIPAN et al., 2012).

Consistent with some previous studies (GLICKMAN et al., 1997; PIPAN et al., 2012) male dogs had an overall increased risk of developing GDV compared with female dogs. In contrast, EVANS and ADAMS (2010) reported a higher GDV risk for female dogs (131/238, 55%) in comparison to male dogs (107/238, 45%).

The majority of dogs with GDV were middle-aged (8.42±3.13 years), similar to the results of previous studies found in 166 dogs (7.30±3.50 years) (BECK et al., 2006) and 1114 dogs (6 years, range 1 to 15 years) (PIPAN et al., 2012). However, another study in 1660 dogs showed that the mean age was 2.3 years lower (GLICKMAN et al., 2000 a,b). The results of the present study may have been biased by the local dog population.

The mortality rate of GDV reported in earlier retrospective studies varies from 27 to 43% (BETTS et al., 1974; MUIR, 1982; MATTHIESEN, 1983). The 13.91% overall mortality rate in this study is in accordance with more recent publications describing a mortality rate of 9.8-23.4% (BROCKMAN et al., 1995; BROURMAN et al., 1996; MACKENZIE et al., 2010; ZACHER et al., 2010; GREEN et al., 2011; BEER et al., 2013). Adequate shock treatment, resuscitation, and monitoring as well as accurate surgical planning and postoperative intensive care are factors that have been shown to significantly improve the prognosis of dogs with GDV (BETTS et al.,1974; MUIR, 1982; MATTHIESEN, 1983; LEIB and BLASS, 1984; CARTER, 1990; VAN SLUIJS, 1990; ELLISON, 1993; MEYER-LINDENBERG et al., 1993; HOSGOOD, 1994; BROCKMAN et al., 1995; BROURMAN et al., 1996; BROCKMAN and HOLT, 2000; MONNET, 2003; WINKLER et al., 2003; BECK et al., 2006; GREEN et al., 2011).

In this study, ten of 110 (9.09%) patients underwent partial or total splenectomy. This number is lower than the 20–23% found in previous studies (BROCKMAN et al., 1995; BROURMAN et al., 1996; MACKENZIE et al., 2010), but within the range of more recent publications: 26 of 166 (15.7%) (BECK et al., 2006) and 9 of 84 (10%) (GREEN et al., 2011). The reason for the differences between the present study and earlier studies remains unclear. In the present study, either partial gastrectomy alone or gastrectomy and partial or total splenectomy were performed in 7.27% (eight of 110 dogs) of our GDV patients. In contrast to these findings, previously reported rates of percental gastrectomy were higher. BROCKMAN et al. (1995) reported gastrectomy in 14% (26 of 182), BROURMAN et al. (1996) in 17% (23 of 132) of GDV patients. ZACHER et al. (2010) published 25% (14 of 56), GREEN et al. (2011) 12% (9 of 74 dogs) and MACKENZIE et al. (2010) performed partial gastrectomy or gastrectomy with additional splenectomy in 20% (58 of 294 dogs) of their GDV patients. In the most recent study BEER et al. (2013) reported a gastrectomy rate of 16% (12 of 73 dogs). Although the percentage of gastrectomies was almost twice as high as in our study, we could only find a significant difference in gastrectomy rates comparing our data to BROURMAN et al. (1996), MACKENZIE et al. (2010), and ZACHER et al. (2010).

However, the decision to perform gastrectomy depends upon the extent of actual gastric damage, the subjective assessment of gastric damage by the surgeon and the owner's willingness to pursue treatment. Little information on the extent of gastric abnormalities or the decision-making process is provided by the authors of previous studies. Thus, a broad variation of individual estimations of gastric wall necrosis exists and an over interpretation of the

indication for partial gastrectomy seems possible. Since our intra- and postoperative mortality rates did not differ significantly from previously published data, bias due to a higher rate of intraoperative euthanasia or postoperative deaths caused by gastric wall necrosis after misinterpretation of gastric wall vitality seems to be unlikely. Nevertheless the lower rates of gastric wall resections should be interpreted cautiously. Dogs that have been showing clinical signs for more than six hours prior to examination require partial gastrectomy significantly more often (BECK et al., 2006). Thus, it could be postulated that the number of patients presented with gastric necrosis in the present case series was low either because the stomach was decompressed early (HALL, 1989; MONNET, 2003; LUNCA et al., 2005; GOODRICH et al., 2013) or because of an accidental variation in the rate of gastric necrosis as it has been reported, even from the same institution (BROCKMAN et al., 1995; DE PAPP et al., 1999). This proportion may further have been lowered by the number of dogs that had been euthanized prior to treatment. However, there were no data to disprove this hypothesis in the present study; the decision to perform partial gastrectomy was always left to the surgeon, who relied on gastric wall thickness and colour. Common theories (MATHHIESEN, 1985; GREEN et al., 2011) are that a dark grey colour is a sign of ischemia, that a reduced thickness with the absence of seromuscular layer slippage between the fingers is a sign of necrosis, and that the absence of peristaltic waves is an indication of reduced viability. However, these criteria are subjective, and they are only accurate in 80% of cases (MATTHIESEN, 1985, 1987; MONNET, 2003).

Although canine patients that have undergone partial gastrectomy reportedly have a poor prognosis, this was not observed in the present study. Of the eight dogs that underwent partial gastrectomy alone or in combination with either partial or total splenectomy, only one died. Although statistical analysis could not be performed due to the low case number, this seems to be in accordance with the results reported by BECK et al. (2006), who found that partial gastrectomy is not a significant risk factor for death, and MACKENZIE et al. (2010), who reported that the postoperative mortality rate for dogs that underwent partial gastrectomy as the only additional surgical procedure was not significantly higher than that for dogs that did not undergo gastrectomy.

In the present study, a combination of splenectomy and partial gastrectomy seemed to carry a higher postoperative mortality rate (one of three dogs). However, this should be interpreted cautiously because of the low number of patients evaluated. BECK et al. (2006) reported that dogs that underwent partial gastrectomy had a significantly higher risk of developing postoperative complications such as sepsis, peritonitis, arrhythmia, and disseminated intravascular coagulation. Although the results of the present series do not reflect these previous findings, it must be stressed that the cause of the postoperative deaths was not always known because pathological examinations were not available from all dogs.

Conclusion

The present study showed a lower number of partial gastrectomies in dogs with GDV when compared with previous data.

This exceptionally lower number of patients diagnosed with stomach wall necrosis that subsequently underwent partial gastrectomy may have different reasons (early decompression of the stomach, early presentation at the clinic, variation in the rate of gastric necrosis, preoperative euthanasia). It may also indicate an over interpretation of the signs for stomach wall necrosis and therefore a more frequent decision for partial gastrectomy in previous studies on canine GDV. Therefore, more objective methods of assessing gastric wall viability in patients with GDV are required.

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Fazit für die Praxis:

In dieser retrospektiven Studie an Hunden mit akutem Magendilatations-Volvulus-Syndrom („Magendrehung“) wurden Gastrektomien wegen Magenwandnekrose nur bei 7 % der Patienten durchgeführt. Diese im Vergleich zu vorangegangenen Studien (12–25 % Gastrektomien) geringere Rate an Gastrektomien könnte auf eine möglicherweise gängige Überinterpretation von Magenwandnekrosen nach Magendrehung hindeuten. Obwohl die Rate an Magenwandteilresektionen nach Magendrehung auch durch andere Faktoren beeinflusst worden sein könnte, sollte die Beurteilung der Magenwandvitalität bis zur Festlegung objektiver Kriterien mit größtmöglicher Vorsicht getroffen werden.

References

BECK, J.J., STAATZ, A.J., PELSUE, D.H., KUDNIG, S.T., MACPHAIL, C.M., SEIM, H.B., 3RD, MONNET, E. (2006): Risk factors associated with short-term outcome and development of perioperative complications in dogs undergoing surgery because of gastric dilatation-volvulus: 166 cases (1992–2003). J Am Vet Med Assoc **229**, 1934–1939.

BEER, K.A., SYRING, R.S., DROBATZ, K.J. (2013): Evaluation of plasma lactate concentration and base excess at the time of hospital admission as predictors of gastric necrosis and outcome and correlation between those variables in dogs with gastric dilatation-volvulus: 78 cases (2004–2009). J Am Vet Med Assoc **242**, 54–58.

BETTS, C.W., WINGFIELD, W.E., GREEN, R.W. (1974): A retrospective study of gastric dilatation-torsion in the dog. J Small Anim Pract **15**, 727–734.

BROCKMAN, D.J., HOLT, E.D. (2000): Management protocol for acute gastric dilatation–volvulus syndrome in dogs. Compend Contin Educ Practicing **22**, 1025–1034.

BROCKMAN, D.J., WASHABAU, R.J., DROBATZ, K.J. (1995): Canine gastric dilatation/volvulus syndrome in a veterinary critical care unit: 295 cases (1986-1992). J Am Vet Med Assoc **207**, 460–464.

BROOME, C.J., WALSH, V.P. (2003): Gastric dilatation-volvulus in dogs. N Z Vet J **51**, 275–283.

BROURMAN, D.J., SCHERTEL, E.R., ALLEN, D.A., BRICHARD, S.J., DEHOFF, W.D. (1996): Factors associated with perioperative mortality in dogs with surgical managed gastric dilatation-volvulus: 137 cases (1988–1993). J Am Vet Med Assoc **208**, 1855–1858.

BUBER, T., SARAGUSTY, J., RANEN, E., EPSTEIN, A., BDOLAH-ABRAM, T., BRUCHIM, Y. (2007): Evaluation of lidocaine treatment and risk factors for death associated with gastric dilatation and volvulus in dogs: 112 cases (1997–2005). J Am Vet Med Assoc **230**, 1334–1339.

CARTER, W.O. (1990): Aortic thromboembolism as a complication of gastric dilatation/volvulus in a dog. J Am Vet Med Assoc **196**, 1829–1830.

DE PAPP, E., DROBATZ, K.J., HUGHES, D. (1999): Plasma lactate concentration as a predictor of gastric necrosis and survival among dogs with gastric dilatation-volvulus: 102 cases (1995–1998). J Am Vet Med Assoc **215**, 49–52.

ELLISON, G.W. (1993): Gastric dilatation volvulus. Surgical prevention. Vet Clin North Am Small Anim Pract **23**, 513–530.

EVANS, K.M., ADAMS, V.J. (2010): Mortality and morbidity due to gastric dilatation-volvulus syndrome in pedigree dogs in the UK. J Small Anim Pract **51**, 376–381.

GLICKMAN, L.T., GLICKMAN, N.W., SCHELLENBERG, D.B., SIMPSON, K., LANTZ, G.C. (1997): Multiple risk factors for the gastric dilatation-volvulus syndrome in dogs: a practitioner/owner case-control study. J Am Anim Hosp Assoc **33**, 197–204.

GLICKMAN, L.T., GLICKMAN, N.W., SCHELLENBERG, D.B., RAGHAVAN, M., LEE, T.L. (2000a): Incidence of and breed-related risk factors for gastric dilatation-volvulus in dogs. J Am Vet Med Assoc **216**, 40–45.

GLICKMAN, L.T., GLICKMAN, N.W., SCHELLENBERG, D.B., RAGHAVAN, M., LEE, T. (2000b): Non-dietary risk factors for gastric dilatation-volvulus in large and giant breed dogs. J Am Vet Med Assoc **217**, 1492–1499.

GOODRICH, Z.J., POWELL, L.L., HULTING, K.J. (2013): Assessment of two methods of gastric decompression for the initial management of gastric dilatation-volvulus. J Small Anim Pract **54**, 75–79.

GREEN, T.I., TONOZZI, C.C., KIRBY, R., RUDLOFF, E. (2011): Evaluation of initial plasma lactate values as a predictor of gastric necrosis and initial and subsequent plasma lactate values as a predictor of survival in dogs with gastric dilatation-volvulus: 84 dogs (2003-2007). J Vet Emerg Crit Care (San Antonio) **21**, 36–44.

HAGLUND, U. (1993): Systemic mediators released from the gut in critical illness. Crit Care Med **21**, 15–18.

HALL, J.A. (1989): Canine gastric dilatation-volvulus update. Semin Vet Med Surg (Small Anim) **4**, 188–193.

HOSGOOD, G. (1994): Gastric dilatation-volvulus in dogs. J Am Vet Med Assoc **204**, 1742–1747.

LEIB, M.S., BLASS, C.E. (1984): Gastric dilatation-volvulus in dogs: An update. Compend Contin Educ Pract Vet **6**, 961–967.

LUNCA, S., RIKKERS, A., STANESCU, A. (2005): Acute massive gastric dilatation: severe ischemia and gastric necrosis without perforation. Rom J Gastroenterol **14**, 279–283.

MACKENZIE, G., BARNHART, M., KENNEDY, S., DEHOFF, W., SCHERTEL, E. (2010): A retrospective study of factors influencing survival following surgery for gastric dilatation-volvulus syndrome in 306 dogs. J Am Anim Hosp Assoc **46**, 97–102.

MATTHIESEN, D.T. (1983): The gastric dilatation-volvulus complex: medical and surgical considerations. J Am Anim Hosp Assoc **19**, 925–932.

MATTHIESEN, D.T. (1985): Partial gastrectomy as treatment of gastric volvulus: results in 30 dogs. Vet Surg **14**, 185–193.

MATTHIESEN, D.T. (1987): Indications and techniques of partial gastrectomy in the dog. Semin Vet Med Surg (Small Anim) **2**, 248–256.

MCCOY, D.M., SYKES, G.P., HOFFER, R.E., HARVEY, H.J. (1982): A Gastropexy technique for permanent fixation of the pyloric antrum. J Am Anim Hosp Assoc **18**, 763–768.

MEYER-LINDENBERG, A., HARDER, A., FEHR, M., LUERSSEN, D., BRUNNBERG, L. (1993): Treatment of gastric dilatation-volvulus and a rapid method for prevention of relapse in dogs: 134 cases (1988-1991). J Am Vet Med Assoc **203**, 1303–1307.

MONNET, E. (2003): Gastric dilatation-volvulus syndrome in dogs. Vet Clin North Am Small Anim Pract **33**, 987–1005.

MUIR, W.W. (1982): Gastric dilatation-volvulus in the dog, with emphasis on cardiac arrhythmias. J Am Vet Med Assoc **180**, 73–742.

ORTON, E.C., MUIR, W.W., 3RD (1983a): Hemodynamics during experimental gastric dilatation-volvulus in dogs. Am J Vet Res **44**, 1512–1515.

ORTON, E.C., MUIR, W.W., 3RD (1983b): Isovolumetric indices and humoral cardioactive substance bioassay during clinical and experimentally induced gastric dilatation-volvulus in dogs. Am J Vet Res **44**, 1516–1520.

PIPAN, M., BROWN, D.C., BATTAGLIA, C.L., OTTO, C.M. (2012): An Internet-based survey of risk factors for surgical gastric dilatation-volvulus in dogs. J Am Vet Med Assoc **240**, 1456–1462.

SUGA, H., HISANO, R., HIRATA, S., HAYASHI, T., NINOMIYA, I. (1982): Mechanism of higher oxygen consumption rate: pressure-loaded vs. volume-loaded heart. Am J Physiol **242**, H942–948.

VAN SLUIJS, F.J. (1990): Splenomegaly in stomach torsion. Tijdschr Diergeneeskd **115**, 999.

VAN SLUIJS, F.J., HAPPÈ, R.P. (1985): The Stomach. In: SLATTER, D.H. (Ed): Textbook of Small Animal Surgery. 1st ed., Saunders, Philadelphia, 689–699.

WINGFIELD, W.E., CORNELIUS, L.M., DEYOUNG, D.W. (1974): Pathophysiology of the gastric dilation-torsion complex in the dog. J Small Anim Pract **15**, 735–739.

WINGFIELD, W.E., CORNELIUS, L.M., ACKERMAN, N., DEYOUNG, D.W. (1975a): Experimental acute gastric dilatation and torsion

in the dog–2. Venous angiographic alterations seen in gastric dilation. J Small Anim Pract **16**, 55–60.

WINGFIELD, W.E., BETTS, C.W., GREENE, R.W. (1975b): Operative techniques and recurrence rates associated with gastric volvulus in the dog. J Small Anim Pract **16**, 427–432.

WINKLER, K.P., GREENFIELD, C.L., SCHAEFFER, D.J. (2003): Bacteremia and bacterial translocation in the naturally occurring canine gastric dilatation-volvulus patient. J Am Anim Hosp Assoc **39**, 361–368.

ZACHER, L.A., BERG, J., SHAW, S.P., KUDEJ, R.K. (2010): Association between outcome and changes in plasma lactate concentration during presurgical treatment in dogs with gastric dilatation-volvulus: 64 cases (2002–2008). J Am Vet Med Assoc **236**, 892–897.