doi: 10.17221/8496-VETMED

Risk factors for gastric dilatation and volvulus in central Europe: an internet survey

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ABSTRACT: The aim of this internet-based questionnaire was to determine risk factors for the development and survival of gastric dilatation and volvulus (GDV) in dogs in central Europe. The questionnaire focused on general information, feeding and elimination behaviour, family history, personality and routine habits, was freely distributed on the internet. Respondents were recruited by e-mail, and announcement of the survey on websites focused on dogs or breeder clubs and flyers in veterinary clinics and at dog shows. Responses from the owners of 785 dogs were analysed. Data underwent descriptive statistical and logistic regression analysis. Factors associated with an increased risk of GDV are intact male, specific breed, pet food and first-degree relative with gastric-dilatation and volvulus. In contrast, low risk was observed in spayed females, dogs eating meals with large particles, dogs with frequent defecation or in dogs kept at home. Non-survivors had a significantly longer time between food consumption and the development of clinical signs than survivors. We conclude that the risk of GDV development is associated with several factors. Some of these can be influenced by the owner or veterinarian.

Keywords: gastric dilatation and volvulus syndrome; prognostic factors; dog

Gastric dilatation and volvulus syndrome (GDV) is an acute and progressive life-threatening disease occurring mainly in dogs, but it has also been described in polar bears (Amstrup and Nielsen 1989), cats (Formaggini et al. 2008) and guinea pigs (Mitchell et al. 2010). The estimated incidence was approximately 0.3–1.2% (in the years 1992–1999) with a mortality of 10–33%, but after surgical therapeutic intervention, this level was about 6% (Glickman et al. 1994; Brockman et al. 1995; Dennler et al. 2005; Beck et al. 2006).

The aetiology of GDV is not yet known, but many predisposing factors have been described, including decreased gastric motility, inflammatory bowel disease or other signs of impaired gastrointestinal function (Hall et al. 1993; Braun et al. 1996; Beck et al. 2006). Many studies have focused on the identification of endogenous and exogenous factors which may help in the identification of dogs at risk of GDV. An increased risk of GDV exists in older dogs of large breeds, e.g. Great Dane, German Shepherd, Weimaraner, Saint Bernard, Irish Setter, Doberman Pincher, Poodle or Bloodhound (Glickman et al. 1994; Brockman et al. 1995; Glickman et al. 1997; Evans and Adams 2010). The ratio of thoracic width and depth in Irish Setters has an influence on GDV, which may be one of the factors explaining the suspected genetic predisposition (Schaible et al. 1997; Schellenberg et al. 1998; Glickman et al. 2000b). GDV seems to be more frequent in males than in females and there is no influence of castration on development of disease (Glickman et al. 1994; Glickman et al. 1997; Theyse et al. 1998).

With respect to food intake, rapid feeding, feeding from an elevated bowl, change of feeding time or small particle size of food seems to increase the risk of GDV; with regard to the number of meals per day, there are inconclusive results (Glickman et al. 1997; Herbold et al. 2002; Glickman et al.

doi: 10.17221/8496-VETMED

2010a). Many studies have focused on seasonal factors and the incidence of GDV, but the results have been inconsistent. Whilst some authors describe a higher incidence in winter time (Herbold et al. 2002; Moore et al. 2008), summer predominates in other studies (Dennler et al. 2005). Also, increased mean or maximal daily air temperature was described as predisposing for the disease (Herbold et al. 2002; Dennler et al. 2005). The influence of atmospheric pressure on disease development is not clear, but increased minimal daily atmospheric pressure seems to pose a risk (Dennler et al. 2005; Moore et al. 2008; Levine et al. 2009).

Finally, stressful situations (dog being cared for by a different person, visiting, travelling, changing location or higher physical activity) and fearful temperament seem to increase the risk of disease development (Glickman et al. 1997). Since there is limited information about predisposing factors outside the US and the conditions in which dogs are kept vary, the aim of this study was to evaluate the described predisposing factors for GDV development in dogs in central Europe.

MATERIAL AND METHODS

Data collection. Data were collected using an internet-based questionnaire using a questionnaire form (GoogleDrive, Google, CA, USA). The survey was initiated on 20th October, 2012 and data were collected from 20th October, 2012 to January 31st, 2014. The questionnaire was in Czech and Slovak language only (English version appended as Additional Material).

Recruitment of survey participants. Survey participants were recruited by e-mail and an electronic link that was posted on websites for dog owners. E-mails for recruitment were collected from kennel websites and the websites of kennel clubs for large-breed dogs bred in the Czech Republic. Flyers with links to the website were distributed through some veterinary clinics (e.g. university hospital) and dog shows (e.g. International Dog Show in Brno). The distribution of the questionnaire was not restricted.

Survey characteristics. The survey was designed for three groups of participants: the first group was the control, and included dogs older than five years weighing more than 30 kg or taller than 50 cm without gastropexy; the second group included dogs with a history of GDV that survived; and the third group consisted of dogs that had died due to GDV.

The survey had two parts: part A was the same for all three groups, while part B was focused on GDV and was accessible only for the second and third groups. Part A consisted of four segments: the first section was on general information (identification of the owner, location, breed, sex, age and weight), the second part was focused on feeding and elimination habits (type of food, frequency of feeding, intake of treats, size of particles in food, grass eating, frequency of vomiting, diarrhoea, eructation and defecation), the third part asked about GDV in the dog's family and the presence of other dogs with or without GDV in the same home and the final part was focused on pet behaviour (activity, frequency of walking outside). Part B asked for more detail about GDV (date and time of GDV, time from feeding to GDV, specification of last food before GDV, time until arrival to hospital, character of day (special events) and treatment).

Statistical analysis. Data were analysed with statistical software (MedCalc Software bvba, Ostend, Belgium; Stastitica 6.0, Statsoft, Inc., Tulsa, USA). Evaluation of risk of GDV was performed using logistic regression and frequency was tested with the χ^2 test. For the first part of the work, the control group was compared with the dogs with GDV (both survivors and non-survivors) using logistic regression (part A of questionnaire). Significant risk factors were the same in the univariate and multivariate analysis. Results from univariate analysis are shown. In question No. 11 and 12, the answers were first sorted into two groups (question No. 11 – inside even for some time and outside, question No. 12 – any family member or none) and after that again underwent analysis for each category. From question No. 15 onwards answers were divided into three categories: meals with dry kibbles/meals with kibbles other than dry kibbles/no kibbles in food. Meals containing kibbles encompassed both meals with dry and meals with other kind of kibbles. Only dry food signified meals with dry kibbles. From question No. 28 onwards answers were divided into two groups: any activity or no activity.

For the evaluation of risk factors associated with mortality, survivors and non-survivors were compared using the χ^2 test (part B of questionnaire). Comparison of age and weight between groups was performed using the Mann-Whitney *U* test. The level of statistical significance was set at $P < 0.05$.

doi: 10.17221/8496-VETMED

RESULTS

Characteristics of responders

A total of 844 responses to the questionnaire were obtained. Fifty-nine (7.0%) responses were excluded due to the low age or size of the dogs, so the remaining 785 (93.0%) were submitted for statistical analysis.

Seventy-one responses were obtained from the Slovak Republic (9.0%), two were from Austria (0.3%) and the rest (90.7%) were from the Czech Republic. From all responses, 536 dogs were used as control dogs (68.3%), 127 (16.2%) were dogs which had survived GDV and belonged in the second group and 122 dogs (14.5%) died due to GDV.

The general description of all dogs included in this study is shown in Table 1. The median age of dogs was nine years (min-max, seven months to 18 years), while median weight was 40.0 kg (17.0–95.0 kg). There were significant differences in age and weight between the control group and dogs with GDV ($P < 0.0001$).

A total of 316 intact females (40.2%), 111 spayed females (14.2%), 308 intact males (39.2%) and 40 (5.1%) castrated males were included; ten owners (1.3%) refused to respond to this question. There was a significant difference in sex distribution between control dogs and dogs with GDV ($P < 0.001$). Intact males were at higher risk of GDV ($P = 0.02$), whilst the number of spayed females with GDV was lower than expected ($P < 0.001$). There was no significant difference in sex distribution between survivors and non-survivors ($P = 0.35$).

The most represented breed was German Shepherd, with 131 responses (16.6%), followed by Bernese Mountain Dog (n =70, 8.9%), Rhodesian Ridgeback (n = 59, 7.5%), Great Dane (n = 52, 6.6%), Hovawart (n = 41, 5.3%), Newfoundland (n = 34, 4.3%), Labrador retriever (n = 30, 3.8%), Golden retriever (n = 29, 3.7%), Irish Wolfhound (n = 26, 3.4%), Boxer (n = 21, 2.7%), Leonberger (n = 20, 2.5%) and cross-breeds (n = 20, 2.5%). The remaining 252 dogs (32.2%) belonged to 60 different breeds. There was a significant difference in breed distribution between

Table 1. Study population overview

	Control dogs	Dogs with GDV	
		survivors	non-survivors
		mean (min–max)	
Age (year)	9.5 (5.0–18.0)	8.0 (1.5–15.0)	7.0 (0.6–16.0)
Weight	38.0 (17.0–90.0) kg 83.8 (37.5–198.4) lbs	42.0 (20.0–95.0) kg 92.6 (44.1–209.4) lbs	45.0 (17.0–95.0) kg 99.2 (37.5–209.4) lbs
Sex and neuter status		*n* (%)	
Female intact	219 (41.1)	56 (45.2)	41 (34.4)
Female spayed	96 (18.1)	8 (6.4)	7 (5.9)
Male intact	187 (35.1)	55 (44.4)	66 (55.5)
Male castrated	30 (5.7)	5 (4.0)	5 (4.2)
Breed (n > 20)		*n* (%)	
German Shepherd	91 (17.0)	21 (16.5)	19 (15.6)
Bernese Mountain Dog	48 (9.0)	10 (7.8)	12 (9.8)
Rhodesian Ridgeback	40 (7.5)	13 (10.2)	6 (4.9)
Great Dane	21 (3.9)	17 (13.4)	14 (11.5)
Hovawart	31 (5.8)	6 (4.7)	4 (3.4)
Newfoundland Dog	20 (3.7)	4 (3.2)	10 (8.2)
Labrador Retriever	29 (5.4)	0 (0)	1 (0.8)
Golden Retriever	26 (4.8)	2 (1.6)	1 (0.8)
Irish Wolfhound	8 (1.5)	12 (9.4)	6 (4.9)
German Boxer	16 (3.0)	3 (2.4)	2 (1.6)
Leonberger	17 (3.2)	2 (1.6)	1 (0.8)
Other pure-breed	171 (31.9)	36 (28.4)	45 (36.9)
Cross-breed	18 (3.3)	1 (0.8)	1 (0.8)

doi: 10.17221/8496-VETMED

control dogs and dogs with GDV ($P < 0.001$). Great Danes, Irish Wolfhounds ($P < 0.0001$) and Central Asian Shepherd Dogs ($P < 0.05$) had a higher risk of developing GDV. On the other hand, Labrador retrievers and Golden retrievers seemed to be at lower risk for GDV development ($P < 0.05$). There was no significant difference in breed distribution between survivors and non-survivors ($P = 0.54$).

Feeding and elimination

Frequency of feeding (once/twice per day or *ad libitum)* did not differ between the groups of dogs with and without GDV ($P = 0.47$). Responders fed different types of diet to their dogs; thus, we had to divide the dogs into two groups: dogs receiving meals without kibbles and dogs eating meals containing kibbles (dry kibbles, kibbles and canned food or kibbles and cooked food). The first group was found to suffer from GDV less than dogs consuming meals containing kibbles (Table 2). Another comparison was between meals composed only of dry kibbles and any other meal; there was no difference between dogs with and without GDV ($P = 0.51$), and the same was true when dogs eating dry kibbles or kibbles with can or cooked food were compared ($P = 0.54$). Another important factor was the size of particles in the meal, with dogs eating meals containing particles larger than 3 cm being at lower risk of GDV development. The intake of treats was connected to GDV development, where dogs eating treats everyday were found to suffer from GDV much less often than other dogs and dogs receiving no treats at all were at significantly higher risk of developing GDV.

Frequency of vomiting, diarrhoea, eructation and grass eating (never, once per month, twice-three times per month, once per week or more than once per week) were not significantly different between control dogs and those with GDV. Frequency of defecation had a tendency ($P = 0.12$ in logistic regression and 0.007 in χ^2 test) towards a lower risk of GDV in dogs defecating more than twice per day.

Family history and owner-hold conditions

GDV was more frequent in dogs with GDV in the family and the highest risk was in dogs whose mother or father suffered from GDV. On the other hand, the incidence of GDV in offspring was similar between controls and dogs with GDV. A high risk of GDV was seen for dogs kept in a house with another dog with a history of GDV and GDV was less frequent in dogs kept with another dog without any history of GDV ($P = 0.02$, χ^2 test). Dogs kept in the house were generally at lower risk of GDV. When the group of dogs spending no time in the house was compared with the group of dogs allowed to spend at least part of the day inside, a tendency for a higher risk of GDV was reported for the first group ($P = 0.06$). A significantly higher risk of GDV ($P < 0.0001$, χ^2 test) was observed in dogs kept out of the house during the night and a lower risk was seen for dogs kept inside during the night. A slightly higher frequency of GDV was observed in dogs kept outside for the entire day, and the opposite was seen for dogs kept inside all day.

Dog behaviour

Dog behaviour during walks (active or passive) had no influence on GDV development ($P = 0.12$). The number of walks per day did not affect the risk of GDV development ($P = 0.63$). Similarly, the performance of any additional activity (agility, dog shows, training) was not associated with the development of GDV ($P = 0.80$).

Dogs with gastric dilatation and volvulus syndrome

Regarding personal data, there was a significant difference in age ($P < 0.05$), but not weight ($P = 0.9$) between survivors and non-survivors. There was no significant difference between date of GDV occurrence ($P = 0.88$), with the highest number of GDV cases in September ($n = 24$, 11.3%) and the lowest in February, May, July and October (all $n = 15$, 7.1%). The start of clinical signs was between 5 pm and 12 pm in most of the dogs (57%). There was no significant difference in the time elapsed between the ingestion of food and the start of clinical signs, but a tendency ($P = 0.06$) towards onset of disease immediately after food intake (23%) and more than > 10 h after food intake (13%) was noticed. There was a significant difference in the onset of clinical signs between survivors and non-survivors ($P < 0.0001$). Non-survivors usually exhibited a longer

doi: 10.17221/8496-VETMED

Table 2. Results from logistic regression analysis of variables (risk of GDV)

Condition (number of question)	χ^2	*P*	Category	*n*	*P*	OR	95% CI
Nationale							
Breed (4)	104.4	< 0.0001	German Shepherd	131	–	1.0	–
			Hungarian Vizsla	6	0.995	0.0	–
			Great Dane	52	0.0004	3.83	1.723–6.544
			Rhodesian Ridgeback	59	0.818	1.081	0.558–2.092
			Golden Retriever	29	0.036	0.263	0.075–0.917
			Labrador Retriever	30	0.013	0.078	0.010–0.596
			Irish Setter	6	0.326	2.275	0.440–11.763
			German Boxer	21	0.532	0.711	0.244–2.074
			Rottweiler	12	0.137	0.207	0.026–1.657
			Newfoundland Dog	34	0.240	1.25	0.732–3.466
			Bernese Mountain Dog	70	0.896	1.042	0.557–1.952
			Irish Wolfhound	26	0.0004	5.119	2.056–12.743
			Doberman Pinscher	17	0.553	0.7	0.215–2.280
			Leonberger	20	0.163	0.402	0.111–1.448
			Belgian Shepherd	14	0.217	0.379	0.081–1.773
			Central Asian Shepherd Dog	11	0.034	3.130	1.103–14.370
			St. Bernard Dog	8	0.300	0.325	0.039–2.730
			Hovawart	41	0.450	0.734	0.328–1.640
			Great Pyrenees	5	0.618	0.569	0.062–5.251
			Cross-breed	20	0.073	0.253	0.056–1.141
			Akita	9	0.860	1.138	0.271–4.777
			Weimaraner	4	0.813	0.758	0.076–7.515
			Schnauzer	14	0.147	2.275	0.749–6.915
			Greater Swiss Mountain Dog	8	0.261	2.275	0.542–9.554
			Alaskan Malamute	10	0.068	3.25	0.913–12.758
			White Swiss Shepherd Dog	8	0.300	0.325	0.039–2.730
			Bordeaux Mastiff	6	0.326	2.275	0.440–11.763
			Slovak Cuvac	6	0.087	4.55	0.801–25.862
			Czechoslovakian Wolfdog	6	0.478	0.455	0.052–4.021
			Fila Brasileiro	10	0.213	2.275	0.624–8.299
			Beauceron	6	0.478	0.455	0.052–4.021
			Other	86	0.811	1.076	0.592–1.953
Sex (5)	20.47	< 0.0001	male	308	0.02	1.46	1.049–2.034
			castrated male	40	0.46	0.75	0.354–1.601
			female	316	–	1.0	–
			spayed female	111	0.0006	0.35	0.195–0.639
Holding conditions							
GDV at house (9)	29.10	< 0.0001	no	688	–	1.0	–
			yes	65	< 0.0001	4.168	2.453–7.081

doi: 10.17221/8496-VETMED

Table 2 to be continued

Condition (number of question)	χ^2	*P*	Category	*n*	*P*	OR	95% CI
Other dog at home (10)	4.686	0.03	no	129	0.03	1.548	1.046–2.290
			yes	640	–	1.0	–
Allowed to be in the house (daily) (11)	2.776	0.0957	no	339	0.0955	1.294	0.0955
			yes	446	–	1.0	–
Stabling (11)	28.255	< 0.0001	outside	339	–	1.0	–
			in house	188	0.039	0.660	0.444–0.980
			in house with possibility of going out	96	0.0073	1.872	1.184–2.691
			inside during night	162	0.0013	0.482	0.310–0.752
GDV in the family (12)	25.54	< 0.0001	no	584	–	1.0	–
			yes	181	< 0.001	2.441	1.730–3.443
Family member with GDV (12)	43.098	< 0.0001	none	584	–	1.0	–
			mother or father	74	< 0.0001	3.397	2.074–5.563
			brother or sister	7	0.992	0.000	–
			unrelated brother or sister	47	0.047	1.855	1.007–3.416
			other family member	34	0.737	1.139	0.532–2.435
			offspring	19	0.147	1.988	0.785–5.033
Feeding and elimination							
frequency of feeding (13)	0.449	0.799	once per day	315	0.539	0.906	0.661–1.241
			twice per day	416	–	1.0	–
			ad libitum	40	0.705	0.872	0.430–1.769
Intake of treats (14)	23.22	< 0.0001	occasionally or never	90	< 0.0001	2.933	1.821–4.721
			once per week	95	0.047	1.631	1.005–2.648
			2–3 times per week	201	0.002	1.786	1.231–2.590
			everyday	370	–	1.0	–
Meal containing kibbles (15)	7.67	0.0056	yes	693	–	1.0	–
			no	92	0.009	0.486	0.283–0.834
Only dry food (15)	0.399	0.527	yes	233	0.527	1.111	0.802–1.539
			no	551	–	1.0	–
Particle size (18)	27.31	< 0.0001	< 0.5 cm	37	0.689	0.865	0.425–1.761
			0.5–3 cm	524	–	1.0	–
			> 3 cm	187	< 0.0001	0.344	0.224–0.529
Vomiting (19)	10.764	0.029	less or never	524	–	1.0	–
			once per month	80	0.168	0.681	0.394–1.176
			2–3 times per month	53	0.063	0.508	0.249–1.036
			once per week	20	0.086	2.188	0.894–5.356
			more than one per week	9	0.223	0.273	0.033–2.204
Diarrhoea (20)	1.985	0.738	less or never	582	–	1.0	–
			once per month	62	0.954	0.983	0.552–1.750
			2–3 times per month	26	0.879	1.068	0.455–2.503
			once per week	11	0.256	2.002	0.603–6.651
			more than one per week	4	0.328	2.403	0.335–17.202
Eructation (21)	1.875	0.598	less or never	278	–	1.0	–
			sometime (in month)	215	0.351	0.827	0.555–1.232
			frequently (in week)	54	0.258	0.671	0.336–1.339
			after almost every food	61	0.957	0.983	0.535–1.805

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Table 1 to be continued

Condition (number of question)	χ^2	*P*	Category	*n*	*P*	OR	95% CI
Grass eating (22)	1.442	0.486	never	0			
			once per month	231	0.849	1.038	0.705–1.526
			2–3 times per month	0			
			once per week	240	–	1.0	–
			more than one per week	211	0.341	0.821	0.548–1.231
Elimination (23)	11.404	0.003	once per day	147	0.661	0.916	0.618–1.356
			twice per day	536	–	1.0	
			more than twice per day	60	0.003	0.309	0.143–0.665
Personal behaviour							
Activity during walks (24)	1.085	0.297	active	577	–	1.0	–
			passive	208	0.296	1.196	0.855–1.674
Number of walks (27)	1.299	0.522	once per day	244	0.265	1.221	0.858–1.737
			two to three times per day	336	–	1.0	–
			paddock	162	0.854	1.038	0.691–1.560
Other activities (28)	0.059	0.806	none	437	0.806	0.961	0.700–1.319
			yes	294	–	1.0	–

Number in parenthesis is the number of the question in the questionnaire (part A); *P* = level of significance for category and each option, *n* = number of participants, OR = odds ratio, CI = confidence intervals

lasting interval from meal intake to the onset of clinical signs, with 64% of dogs having clinical signs more than 4 h after meal intake and 68% of survivors displaying clinical signs within 4 h of meal intake.

Seventy-seven percent of dogs had the same meal as usual before GDV; the rest of the dogs received something other than their regular meal. There was no difference between survivors and non-survivors in this aspect ($P = 0.31$). Regarding activity between feeding and clinical signs, 80% of dogs were laying or sleeping, 19% were running or jumping and 1% were taking care of puppies. For most of the dogs (85%), there was no special activity on the day of GDV. A minority of dogs were being dog-sat (2%), travelling (3%), attending a dog show (2%) or celebration (5%) or had abnormal physical activity (3%). Thirty-one percent of GDV happened during the weekend or on national holidays, with the rest occurring during the working week. Most of the owners (62%) arrived at the veterinary clinic within one hour of the onset of clinical signs and 81% of them arrived within the first two hours; there was no difference between survivors and non-survivors.

Comparison of breed distribution

We have compared our breed distribution to the number of dogs born in 2004 (median age of dogs in the study was nine years) received from the national kennel register (Bohemian and Moravian Cynological Union). Several differences between expected and observed number of participants are shown in Table 3. Other breeds were distributed as expected.

DISCUSSION

Many predisposing factors for GDV have been described in the past (Glickman et al. 1994; Brockman et al. 1995; Glickman et al. 1997; Glickman et al. 2000a; Evans and Adams 2010). Since most of the studies were performed in the USA or UK where dog-keeping and handling conditions differ from central Europe, we were interested in whether there are similar predisposing factors in this geographical region. In our study, there was a significant difference in age between control dogs and those with GDV. Our questionnaire for control dogs was

doi: 10.17221/8496-VETMED

Table 3. Comparison of breed distribution

Underestimated breeds			Overestimated breeds		
Breed	Observed	Expected	Breed	Observed	Expected
Airedale Terrier	0	4	Akita	9	3
English Springer Spaniel	1	6	Alaskan Malamute	10	5
Bavarian Mountain Dog	1	4	Bernese Mountain Dog	70	22
Border Collie	0	9	Fila Brasileiro	12	6
Briard	0	6	Czechoslovakian Wolfdog	6	3
Bohemian Wire-haired Pointing Griffon	2	15	Dobermann Pincher	17	12
Flat Coated Retriever	2	6	Hovawart	41	15
Bohemian Shepherd	0	8	Irish Wolfhound	26	8
Cane Corso	2	8	Leonberger	20	11
Rough Collie	0	8	Great Dane	53	17
Labrador Retriever	30	54	Newfoundland Dog	34	5
German Shorthaired Pointer	3	26	Rhodesian Ridgeback	59	18
Pointer	0	6			
Tibetan Mastiff	3	7			
Weimaraner	4	14			
Golden Retriever	29	38			

Observed = number of dogs present in the study, expected = expected number of dogs based on data from the kennel register in 2004

addressed to dogs older than five years and only 13% of control dogs were younger than eight years, which is the mean age of dogs with GDV. We set the age limit to older dogs to increase the chance that responders will not suffer from GDV in the future and as 25% of the control dogs had died already without experiencing GDV during their life.

GDV was more frequent in intact males and less frequent in spayed females. This trend was also noticed previously (Glickman et al. 1997; Glickman et al. 2000a), while other groups did not confirm the influence of sex on GDV development (Glickman et al. 1994; Theyse et al. 1998) or found the opposite results (Pipan et al. 2012) with the highest risk of GDV in spayed females. Even though the most represented breed was German Shepherd, the occurrence of GDV was significantly higher in Great Danes, Irish Wolfhounds and Central Asian Shepherd Dogs. Great Danes were also found to be at risk in another study. The low risk of GDV noted in Golden and Labrador retrievers was not described in other studies; in the USA, a low risk of GDV was found in Newfoundland and Rottweiler breeds (Glickman et al. 2000a).

As in a previous study (Theyse et al. 1998), we did not find any influence of frequency of feeding on GDV development. In contrast to our results, others (Glickman et al. 1997; Raghavan et al. 2004) found an increased risk associated with feeding once per day, but it is suggested that total amount of meal is more important than frequency. We found a higher risk of GDV in dogs eating meals containing kibbles. Similarly, a lower risk of GDV was described when consuming canned or table food (Glickman et al. 1997), but it is not clear whether this was for food mixed with kibbles or when served as the only food. We did not find feeding dry kibbles to be a risk factor, in contrast to Pipan et al. (2012). Similarly to the study of Theyse et al. (1998), we found a decreased risk of GDV in dogs eating particles larger than 3 cm in their meals. The reason for this is not clear; it may be that larger particles induce more intensive chewing and food is more quickly digested. Also, as in the study by Glickman et al. (1997), which focused on food available between meals, we found that eating another food (treat) was protective. We did not find any difference in frequency of vomiting, diarrhoea, eructation or grass eating between control dogs and dogs with GDV; only more frequent defecation seems to be connected with a lower risk of GDV. This could be connected to the increased motility of the

doi: 10.17221/8496-VETMED

gastrointestinal tract, which is a possible pathogenic factor in GDV development (Hall et al. 1993).

A higher risk of GDV was found in dogs whose mother or father, but not offspring, suffered from GDV. Similar findings were reported in the study of Glickman et al. (2000b), whilst another study (Glickman et al. 1997) did not find first-degree relatives with GDV to increase risk. A possible genetic influence of GDV has been discussed in connection with thoracic conformation, mainly in Irish Setters (Schaible et al. 1997; Schellenberg et al. 1998). The length of gastric ligaments has also been postulated to play a role (Hall et al. 1994). The presence of dogs with GDV in the home increased the risk of GDV; when both influences were analysed together (first-degree relative and dog with GDV in home), the presence of GDV in the home was more strongly associated with GDV development. Dogs that spent at least part of the day in the house were at lower risk of GDV than dogs kept outside for the whole time. Similar results were obtained previously (Pipan et al. 2012), but they are not in accordance with another earlier study (Glickman et al. 1997).

Based on previous findings, happy dogs are less likely to develop GDV in comparison to fearful and aggressive dogs (Glickman et al. 1997), but the influence of overall physical activity is doubtful (Theyse et al. 1998; Pipan et al. 2012).

Regarding GDV cases, the only clinically important difference between survivors and non-survivors was the time of the onset of clinical signs after feeding. This may be the consequence of individual animal behavior during disease or slower disease development. The character of the meal before GDV had no influence on outcome and almost three-quarters of dogs had received usual food. Also, activity after meal seems to have no influence on GDV, since 80% of dogs did not report any activity. Moreover, exercise after meal appeared to be protective for GDV (Pipan et al. 2012).

There are several limitations of this study. First, because the study was an internet-based questionnaire, answers are biased by the memory of the owners. We tried to avoid false answers by giving the option "I do not remember" or "I do not want to answer" to almost all questions, resulting in different numbers of answers for each question. Also, data related to the duration of clinical signs could be biased by the owner's investigating ability. Second, the diagnosis of GDV is almost impossible to distinguish from pure gastric dilatation based on the clinical signs; however, in all except eight dogs the diagnosis was confirmed during the surgery. From these eight dogs, four were diagnosed based just on clinical signs and four had died before they were presented to the veterinary clinics. We do not think that these dogs would bias the results of this study. Third, the breed prevalence may be biased by the internet activity of breeders or kennel clubs in answering/distribution of the questionnaire, since most of the contacts were achieved through the internet. The differences in breed distribution between this study and the data obtained from the kennel register (year 2004) could lead to the biased results of breed predisposition; however, the fluctuation in the number of puppies among years is quite high. Also, the number of dogs born without pedigree is probably high in our country and may bias the expected population. Fourth, the proportion of the dogs in our study is evidently biased to dogs with GDV (with respect to the estimated incidence in other studies) and in dogs with GDV, towards the non-survivors. Although we used quite strict inclusion criteria for control dogs, the occurrence of GDV in those animals is not known. It is likely that owners who experienced GDV were more interested in the questionnaire. The reason for the high proportion of non-survivors is not clear.

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Received: 2014–10–13
Accepted after corrections: 2015–08–26

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Risk factors for gastric dilatation and volvulus in central Europe: an internet survey

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Veterinarni Medicina 60, 2015 (10): 578–587

Additional material

Questionnaire in Czech and the format used for the internet survey is available at
https://docs.google.com/forms/d/1Hub3th06_YY1qGkA2sAWMK48yMG3wJo05hRBAe-I88Y/formResponse

Type of question (text field, single or multiple choice) is specified for each question.

Part A – all dogs

1. Name: [text field]
2. Address: [text field]
3. Name of the dog: [text field]
4. Breed: [text field]
5. Sex: [single choice]
   - o male
   - o castrated male
   - o female
   - o spayed female
6. Age: [text field]
7. Weight: [text field]
8. The dog is still alive: [single choice]
   - o yes
   - o no
9. There is another dog at the house who has suffered from GDV: [single choice]
   - o yes
   - o no
10. There is another dog at the house who has not suffered from GDV: [single choice]
    - o yes
    - o no
11. Dog is kept: [single choice or text field]
    - o outside
    - o inside in a house or flat
    - o in a house with the possibility of going out
    - o inside during the night and in a paddock during the day
    - o other:
12. The following family member of my dog had GDV: [multiple choice]
    - o mother or father
    - o sib from offspring
    - o relative from same mother or father
    - o offspring
    - o far-distant relative
    - o do not know
    - o no one
    - o I made an inquiry to the owner

13. Dog is fed: [single choice]
    - o once per day
    - o twice per day
    - o more than twice per day or ad libitum
    - o do not want to answer
14. Dog gets treats: [single choice]
    - o everyday
    - o once per week
    - o 2-3 times per week
    - o less than once per week
    - o occasionally or never
    - o do not want to answer
15. Dog is fed (mainly) with: [single choice or text field]
    - o kibbles
    - o kibbles with water or soup or other liquid
    - o kibbles and cooked or canned meal
    - o cooked or canned meal
    - o BARF
    - o other:
16. In case of kibbles, which brand: [text field]
17. If you have changed feeding habits during the life of the dog, please specify: [text field]
18. Biggest particles in food are: [single choice]
    - o less than 0.5 cm
    - o 0.5-3 cm
    - o more than 3 cm (e.g. big pieces of meat)
    - o do not want to answer
19. The dog vomits approximately: [single choice]
    - o 2-3 times per week
    - o once per week
    - o 2-3 times per month
    - o once per month
    - o less or never
    - o do not want to answer or do not know
20. The dog experiences diarrhoea approximately: [single choice]
    - o 2-3 times per week
    - o once per week
    - o 2-3 times per month
    - o once per month
    - o less or never
    - o do not want to answer or do not know
21. The dog eructates approximately: [single choice]
    - o after every meal
    - o frequently (few times per week)
    - o sometimes (few times in month)
    - o less or never
    - o do not want to answer or do not know
22. Dog eats grass approximately (if it grows): [single choice]
    - o 2-3 times per week
    - o once per week
    - o 2-3 times per month

- o once per month
- o less or never
- o do not want to answer or do not know

23. The dog eliminates stools approximately: [single choice]
    - o once per day
    - o twice per day
    - o more than twice per day
    - o do not want to answer or do not know
24. Activity of the dog (e.g. on the walk): [single choice]
    - o more likely to keep running, jumping, active
    - o more likely passive, no tendency for running
25. If you want to specify activity (e.g. in relation to age): [text field]
26. Subjectively, my dog is (in the most active age): [single choice]
    - o hyperactive
    - o active
    - o passive
    - o phlegmatic
    - o do not want to answer
27. Frequency of the walks: [single choice]
    - o once per day
    - o 2-3 times per day
    - o dog is kept in a paddock and is not being walked
    - o do not want to answer
28. Pick appropriate from the list: [multiple choice or text field]
    - o dog visits sport training
    - o dog visits dog shows
    - o dog is used as working dog – e.g. police, service
    - o dog accompanies me to work
    - o none of the above
    - o other:
29. The data that you have supplied concerned a: [single choice]
    - o healthy dog
    - o dog who had GDV

Part B – dogs with GDV

1. The number of GDV episodes experienced by my dog: [single choice]
    - o one
    - o two
    - o more
2. This will be a description of which GDV:
3. Please try to recall the most exact date of the GDV:
4. Please try to recall when the clinical signs started: [single choice]
    - o between midnight and 9 a.m.
    - o between 9 a.m. and 5 p.m.
    - o between 5 p.m. and midnight
    - o do not remember
5. When the clinical signs started in relation to the last meal: [single choice]
    - o immediately
    - o 1 hr after

- 1-2 hrs after
- 2-3 hrs after
- 3-4 hrs after
- 4-6 hrs after
- 6-10 hrs after or later
- do not remember

6. Do you recall what was in the meals before the GDV episode? [text field]
7. Was this a regular meal? [single choice]
   - yes
   - no
   - do not remember
8. Between feeding and GDV the dog was: [multiple choice or text field]
   - trained
   - running
   - jumping
   - rolling
   - resting
   - not under supervision or do not remember
   - other:
9. Which clinical signs did you observe?: [text field]
10. Please try to recall events that happened on the day of the GDV episode [multiple choice and text field]
    - dog was at dog show or trial
    - dog was being cared for by a different person
    - we were having a visitor or we were with the dog at a party
    - dog was travelling
    - dog had increased physical activity
    - it was a Friday, Saturday or Sunday
    - it was on a national holiday like Christmas or Easter
    - it was on New Year's Day
    - it was a regular day
    - other:
11. How quickly after clinical signs did you arrive at the veterinary clinic? [single choice]
    - 1 hr
    - 2 hrs
    - 3 hrs
    - 4-6 hrs
    - 6-10 hrs
    - more than 10 hrs
    - do not remember
12. Diagnosis of GDV was based on: [multiple choice and text field]
    - I recognised the clinical signs
    - I described the clinical signs to the veterinarian
    - The veterinarian performed an X-ray
    - The veterinarian started to treat the dog without an X-ray
    - other:
13. I know that the veterinarian: [multiple choice and text field]
    - performed an X-ray
    - tried to put a tube through the mouth – orogastric tube

- o inserted a needle into the belly – gastrocentesis
- o immediately started the surgery
- o I had left the dog at the clinic so I do not know
- o other:

14. Dog underwent surgery: [single choice]
    - o yes
    - o no
15. If the dog was operated on, did the veterinarian perform a gastropexy – preventive suture of the stomach to the abdominal wall? [single choice]
    - o yes
    - o no
    - o do not know
16. After this episode the dog suffered from GDV again: [single choice]
    - o yes
    - o no

Part C – submission

1. Do you agree with the processing of data from this questionnaire? [single choice]
    - o yes
    - o no
2. Here you can specify any answer: [text field]