

Incidence of and breed-related risk factors for gastric dilatation-volvulus in dogs

Lawrence T. Glickman, VMD, DPH; Nita W. Glickman, MS, MPH; Diana B. Schellenberg, MS†; Malathi Raghavan, DVM, MS; Tana L. Lee, BA

Objective—To compare incidence of and breed-related risk factors for gastric dilatation-volvulus (GDV) among 11 dog breeds (Akita, Bloodhound, Collie, Great Dane, Irish Setter, Irish Wolfhound, Newfoundland, Rottweiler, Saint Bernard, Standard Poodle, and Weimaraner).

Design—Prospective cohort study.

Animals—1,914 dogs.

Procedure—Owners of dogs that did not have a history of GDV were recruited at dog shows, and the dog's length and height and depth and width of the thorax and abdomen were measured. Information concerning the dogs' medical history, genetic background, personality, and diet was obtained from owners, and owners were contacted by mail and telephone at approximately 1-year intervals to determine whether dogs had developed GDV or died. Incidence of GDV based on the number of dog-years at risk was calculated for each breed, and breed-related risk factors were identified.

Results and Clinical Relevance—Incidence of GDV for the 7 large (23 to 45 kg [50 to 99 lb]) and 4 giant (> 45 kg [> 99 lb]) breeds was 23 and 26 cases/1,000 dog-years at risk, respectively. Of the 105 dogs that developed GDV, 30 (28.6%) died. Incidence of GDV increased with increasing age. Cumulative incidence of GDV was 5.7% for all breeds. The only breed-specific characteristic significantly associated with a decreased incidence of GDV was an owner-perceived personality trait of happiness. (*J Am Med Vet Assoc* 2000;216:40–45)

Gastric dilatation-volvulus (GDV) is a syndrome in dogs characterized by rapid accumulation of air in the stomach, malposition of the stomach, increased intragastric pressure, and often, cardiogenic shock. Despite aggressive medical and surgical treatment, fatality rates commonly range from 15 to 24%.^{1,2} Although the etiology and pathogenesis of GDV are not fully understood, specific risk factors have been identified from information in case reports and retrospective reviews.³ Thus, older, purebred large- and giant-breed dogs with a deep and narrow thorax and a first-degree relative (ie, sibling, offspring, parent) that developed

GDV at least once are at higher risk for developing GDV than other dogs. Results of a case-control study⁴ that evaluated 25 different breeds indicated that dogs that ate rapidly and were fed fewer meals per day had an increased susceptibility to GDV than other dogs. Additionally, dogs characterized by their owners as happy or easygoing were at lower risk for GDV, whereas those characterized as nervous or fearful were at higher risk. A case-control study that evaluated Great Danes⁵ found that those fed food that contained only particles < 30 mm in diameter were at increased risk of developing GDV, but feeding frequency and speed of eating were not significant risk factors. In contrast, a case-control study that evaluated Irish Setters⁶ found that those fed once daily or fed a single type of food had a significantly increased risk of developing GDV. These case-control studies were retrospective in design, and information on suspected risk factors was obtained directly from owners only after a dog had already suffered an episode of GDV. This approach increases the potential for differential recall of previous exposures between owners of dogs with GDV and owners of control dogs; differential recall could bias the estimates of GDV risk.⁷

To our knowledge, there are no valid estimates of the total number of dogs that develop GDV in a given year or the probability that any individual dog will have an episode of GDV in its lifetime. The most commonly used measure of the absolute risk of a disease in epidemiologic studies is incidence, defined as the number of new cases of disease that occur in a defined population within a specified period.⁸ Incidence of GDV can only be measured using a longitudinal or prospective approach in which a defined population of dogs that are free of disease at the start is observed over a sufficient period. If the study population at the onset can be assigned to subgroups (eg, cohorts), each with different attributes, characteristics, or exposures, then the risk or incidence of GDV in 1 subgroup (eg, exposed cohort) relative to another (eg, unexposed cohort) can be calculated. Using this prospective approach, suspected risk factors are measured or assessed prior to the onset of disease, thus eliminating the potential for recall bias by dog owners.

A prospective observational study presents a number of practical difficulties. For example, when the outcome measure of interest occurs infrequently, a large number of individuals must be entered into the study and remain under observation for a prolonged time before results can be interpreted. Considerable effort must be expended to keep track of these individuals, thus adding to the expense of a study. Although recognized as perhaps the best observational method for studying diseases in populations, prospective studies have rarely been conducted using companion animals.^{9,10}

From the Department of Veterinary Pathobiology (L. Glickman, Schellenberg, Raghavan, Lee) and the Center for the Human-Animal Bond (N. Glickman), Purdue University, West Lafayette, IN 47907-1243.

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†Deceased.

The objectives of the study presented here were to determine the incidence of GDV in a cohort of purebred dogs comprising several breeds that are considered to be at high risk of developing GDV and identify breed-related risk factors for GDV. A secondary objective was to determine the feasibility of conducting long-term prospective studies using companion animals.

Materials and Methods

Recruitment of dogs and owners—Eleven national breed clubs, namely the Akita, Bloodhound, Collie, Great Dane, Irish Setter, Irish Wolfhound, Newfoundland, Rottweiler, Saint Bernard, Standard Poodle, and Weimaraner, agreed to participate in a prospective study of GDV at Purdue University. Beginning in June 1994 and ending in March 1997, an exhibit designed to educate dog owners about GDV and explain the study was set up at 27 different national or specialty dog shows held throughout the United States. Owners who agreed to participate were asked to provide their name, address, and telephone number, the American Kennel Club's registered name of their dog, weight of their dog, and information regarding whether their dog or any of its first-degree relatives (ie, siblings, offspring, and parents) ever had GDV. Owners also gave written permission allowing the GDV research team to contact them periodically by telephone or mail. Confidentiality of all information provided by owners was emphasized. Dogs were then measured at the show by 1 of the authors (LTG). These measurements included length (humeral deltoid tuberosity to ischium), height at the top of the shoulders (withers), depth and width of the thorax at the level of the costal arch, and depth and width of the abdomen at the level of the umbilicus. Body condition (eg, thin, lean, optimum, overweight, obese) and behavior (eg, signs of fearfulness or aggression) were also recorded. Procedures used in this study were approved by the Committee on the Use of Human Research Subjects and by the Animal Use and Care Committee of Purdue University.

Data collection—Within 30 days of entry into the study, owners were mailed an 8-page questionnaire designed to gather information concerning their dog's current vital status and any history of GDV. Dogs that had developed GDV in the past were excluded from the study. Detailed information about each dog was collected, including age, sex, reproductive history, type of breeding that produced the dog (eg, inbreeding, line-breeding, or out-cross), living conditions, travel and medical history, frequency of eructation and flatulence, and current medical problems and medications. Owners also assessed their dog's personality by assigning a score of 1 to 10 to 10 personality and temperament traits, including excitability, activity level, aggressiveness toward dogs, aggressiveness toward people, submissiveness toward dogs, submissiveness toward people, fearfulness, happiness, trainability, and agitation in response to strangers or environmental changes. Owners were asked to score dogs solely on the basis of their interpretations of these terms; examples of specific behaviors or further explanation were not provided. A score of 1 indicated that the dog never had signs consistent with the trait and 10 indicated that the dog always had signs consistent with the trait. Information was also collected about the type, brand, and amount of commercial dog foods or dietary supplements that each dog ate during a typical day, and owners were asked to list the first 4 ingredients on the label of each item. If noncommercial foods were fed on a regular basis, information was requested about the type and amount fed as well as the method of preparation. Questions also focused on frequency of feeding, placement of the food bowl (on the ground or raised), and amount of exercise and water dogs were allowed before and after meals.

Owners scored the speed at which their dog ate on a scale of 1 to 10, with 1 indicating slow and 10 fast. Again, score was assigned on the basis of the owner's perception and prior experience. Owners were asked to call the research team if their dog developed GDV, died of any cause, or if ownership of the dog was transferred to another person. If at any time during the study notification was received from the owner that a dog developed GDV, the name and telephone number of the veterinarian who provided treatment or made the diagnosis was requested. If the dog died at home, owners were asked how a diagnosis was made. All diagnoses of GDV were confirmed by telephone or mail contact with the veterinarian. Dogs with gastric dilatation without confirmation of volvulus by either necropsy, radiography, or direct observation during surgery were not counted as having GDV.

Regardless of whether owners filled out the initial 8-page questionnaire, follow-up postcards with tear-off prepaid response cards were mailed to all study participants in July 1997, March 1998, and February 1999. Owners were asked whether their dog had developed GDV or died of any cause since the research team had last contacted them. If the answer was yes to the first question, owners provided the date that GDV developed and the outcome (died or survived). If the answer to the second question was yes, owners provided the date and cause of death.

Data management and analysis—Data were analyzed with a statistical software program.^a Incidence of GDV was calculated for each of the 11 breeds, for the 4 giant (body weight, > 45 kg [> 99 lb]) breeds combined (Great Dane, Irish Wolfhound, Newfoundland, Saint Bernard), and for the 7 large (23 to 45 kg [50 to 99 lb]) breeds combined (Akita, Bloodhound, Collie, Irish Setter, Rottweiler, Standard Poodle, Weimaraner) by dividing the number of new cases of GDV reported during the follow-up period by the total number of dog-years of follow-up. For dogs that had > 1 episode of GDV during the study, only the first episode was used for calculating incidence. Each dog followed for 1 year contributed 1 dog-year of follow-up. Follow-up ended at the time a dog first developed GDV, died of any cause, or was lost to follow-up for any reason (eg, owner did not respond to repeated telephone calls or moved and did not leave a forwarding address). The maximum possible follow-up time was 58 months for a dog that was enrolled at the first show in June 1994, was not lost to follow-up, and did not develop GDV or die.

The relationship between breed-specific incidence of GDV and size, body conformation, and personality and temperament was determined by use of linear regression¹¹; mean value of these characteristics for each of the 11 breeds was considered the independent variable and the breed-specific incidence of GDV the outcome or dependent variable. For all size and conformation-related measurements, regression models were created separately for males and females. Characteristics that were significant at $P < 0.2$ in the univariate analyses were included in a separate multivariate linear regression model for male and female dogs. In these models, significance was determined when $P < 0.05$.

Results

Signalment of dogs enrolled—Owners of 1,991 dogs answered initial questions at dog shows, but 77 (3.9%) dogs were excluded because they had a history of GDV. Of the remaining 1,914 dogs that were enrolled in the prospective study, vital status information was obtained for 1,843 (96.3%) dogs at least once during the follow-up period, and answers to questions within the 8-page questionnaire were obtained for 1,660 (86.7%) dogs.

The 1,914 enrolled dogs were evenly distributed

Table 1—Description of the population of purebred large- and giant-breed dogs used in a prospective study to determine the incidence of and breed-related risk factors for gastric dilatation-volvulus (GDV)

Breed	No. of dogs enrolled*	No. of dogs with follow-up information (%)	No. of males	No. of females	Median age in years (range)	Median years follow-up (maximum)
Large breed[†]						
Akita	111	106 (96)	61	45	2.3 (0.5–10.7)	2.0 (2.5)
Bloodhound	122	115 (94)	44	71	2.0 (0.5–10.9)	2.6 (2.8)
Collie	210	196 (93)	92	104	2.2 (0.5–12.1)	2.9 (3.0)
Irish Setter [‡]	256	248 (97)	104	143	3.1 (0.5–13.6)	3.0 (4.8)
Rottweiler	117	110 (94)	43	67	3.0 (0.2–10.2)	2.7 (2.8)
Standard Poodle	132	130 (99)	65	65	2.4 (0.5–14.2)	2.7 (2.8)
Weimaraner	96	96 (100)	40	56	2.1 (0.2–14.6)	2.0 (2.6)
Subtotal	1,044	1,001 (96)	449	551	2.4 (0.2–14.6)	2.6 (4.8)
Giant breeds[§]						
Great Dane	211	198 (94)	86	112	1.9 (0.3–8.0)	3.3 (4.4)
Irish Wolfhound	177	177 (100)	77	100	2.4 (0.4–8.0)	2.8 (2.9)
Newfoundland	298	293 (98)	132	161	2.7 (0.3–12.1)	1.9 (2.0)
Saint Bernard	184	174 (95)	101	73	1.7 (0.2–8.5)	2.0 (2.5)
Subtotal	870	842 (97)	396	446	2.2 (0.2–12.1)	2.0 (4.4)
Total	1,914	1,843 (96)	845	997	2.3 (0.2–14.6)	2.4 (4.8)

*Dogs enrolled at dog shows between June 1994 and March 1997. Follow-up information collected from owners via telephone interviews or mailed questionnaires.
[†]Body weight, 23 to 45 kg (50 to 99 lb). [‡]Sex and age information missing for 1 Irish Setter. [§]Body weight, > 45 kg (99 lb). ^{||}Age information missing for 1 Newfoundland.

Table 2—Incidence of GDV (No. of cases/1,000 dog-years at risk) in purebred large-breed dogs (body weight, 23 to 45 kg)

Breed	Dog-years of follow-up	No. of dogs that developed GDV	Incidence (95% CI)	% of dogs with GDV/y
Akita	198.1	5	25 (3, 47)	2.5
Males	117.0	3	26 (3, 55)	2.6
Females	81.1	2	25 (–10, 60)	2.5
Bloodhound	259.2	10	39 (15, 63)	3.9
Males	91.2	5	55 (7, 103)	5.5
Females	168.0	5	30 (4, 56)	3.0
Collie	482.1	10	21 (8, 34)	2.1
Males	216.9	6	28 (6, 50)	2.8
Females	265.2	4	15 (0, 30)	1.5
Irish Setter*	819.2	20	24 (13, 35)	2.4
Males	348.9	9	26 (9, 43)	2.6
Females	465.7	11	24 (10, 38)	2.4
Rottweiler	254.5	1	4 (–4, 12)	0.4
Males	100.1	1	10 (–10, 30)	1.0
Females	154.4	0	0	0
Standard Poodle	294.6	7	24 (6, 42)	2.4
Males	149.3	5	33 (4, 62)	3.3
Females	145.3	2	14 (–5, 33)	1.4
Weimaraner	192.1	4	21 (0, 42)	2.1
Males	81.8	1	12 (–12, 36)	1.2
Females	110.3	3	27 (–4, 58)	2.7
Total*	2,499.9	57	23 (17, 29)	2.3
Males	1,105.2	30	27 (17, 37)	2.7
Females	1,390.0	27	19 (12, 26)	1.9

*Sex information missing for 1 Irish Setter.

among the 11 breeds (Table 1). Median age of all dogs at the start of the study was 2.3 years (range, 0.2 to 14.6 years). Of the 1,843 dogs for which follow-up information was available, 845 (45.9%) were males and 997 (54.1%) were females; sex and age information were missing for 1 and 2 dogs, respectively. Eighty-five (10.1%) of the males and 164 (16.5%) of the females were neutered. Median duration of follow-up for the 1,843 dogs was 2.4 years (maximum, 4.8 years).

Death rate—During the follow-up period, 193 of 1,843 (10.5%) dogs died; these deaths occurred in 97 of the 1,001 (9.7%) large-breed dogs and 96 of the 842 (11.4%) giant-breed dogs. Of the 193 deaths, 30 (15.5%)

Table 3—Incidence of GDV in purebred giant-breed dogs (body weight, > 45 kg)

Breed	Dog-years of follow-up	No. of dogs that developed GDV	Incidence (95% CI)	% of dogs with GDV/y
Great Dane	586.9	31	53 (34, 72)	5.3
Males	247.7	15	61 (30, 92)	6.1
Females	339.2	16	47 (24, 70)	4.7
Irish Wolfhound	392.0	10	26 (10, 42)	2.6
Males	166.6	6	36 (7, 65)	3.6
Females	225.4	4	18 (0, 36)	1.8
Newfoundland	499.4	5	10 (1, 19)	1.0
Males	221.0	2	9 (–3, 21)	0.9
Females	278.4	3	11 (–1, 23)	1.1
Saint Bernard	346.6	2	6 (–2, 14)	0.6
Males	197.3	0	0	0
Females	149.2	2	13 (–5, 31)	1.3
Total	1,824.9	48	26 (19, 33)	2.6
Males	832.7	23	28 (17, 39)	2.8
Females	992.2	25	25 (15, 35)	2.5

were attributed to GDV. Another 5 dogs were reported by the owner to have died of GDV, but a veterinarian did not confirm the diagnosis. The other common causes of death included cancer (n = 49) and neurologic disease (11). Twenty-four dogs died of unknown causes. The death rate for the 1,001 large-breed dogs (39 deaths/1,000 dog years at risk; 95% confidence interval [CI], 31, 47) was significantly ($P = 0.04$) less than the death rate for the 842 giant-breed dogs (53 deaths/1,000 dog years at risk; 95% CI, 42, 64).

Incidence of GDV—We did not detect a significant difference ($P = 0.49$) in incidence of GDV between large-breed (23 cases of GDV/1,000 dog years at risk; 95% CI, 17, 29) and giant-breed (26 cases of GDV/1,000 dog years at risk; 95% CI, 19, 33) dogs (Tables 2 and 3). During the study, 24 of 1,001 (2.4%) and 23 of 842 (2.7%) of the large- and giant-breed dogs, respectively, had 1 episode of GDV for each year of observation. Of the 105 dogs that developed GDV, 30 (28.6%) died. Incidence of GDV was higher for males than for females among both the large (27 cases/1,000 dog-years at risk vs 19 cases/1,000 dog

years at risk; $P = 0.23$) and giant (28 cases/1,000 dog years at risk vs 25 cases/1,000 dog-years at risk; $P = 0.77$) breeds, but these differences were not significant. Incidence of GDV increased with increasing age in large- and giant-breed dogs, but this increase did not begin in large-breed dogs until 3 years of age, whereas the increase was noticeable earlier in giant-breed dogs (Fig 1). Great Danes and Bloodhounds had the highest incidence of GDV among the giant and large breeds, respectively, whereas Newfoundlands and Rottweilers had the lowest incidence of GDV, respectively (Fig 2 and 3). The cumulative incidence of GDV during the study was 5.7% for both the giant- and large-breed dogs (Fig 4). However, there was considerable variation among the breeds. For example, among the giant breeds, 31 of 198 (15.7%) Great Danes developed GDV versus 2 of 174 (1.2%) Saint Bernards. Among the large breeds, 10 of 115 (8.7%) Bloodhounds developed GDV versus 1 of 110 (1.0%) Rottweilers (Fig 5 and 6).

Breed-related risk factors—Breed-related conformational characteristics among male and female dogs that were positively associated (univariate linear regression analysis, $P < 0.20$) with incidence of developing GDV included thoracic depth-to-width

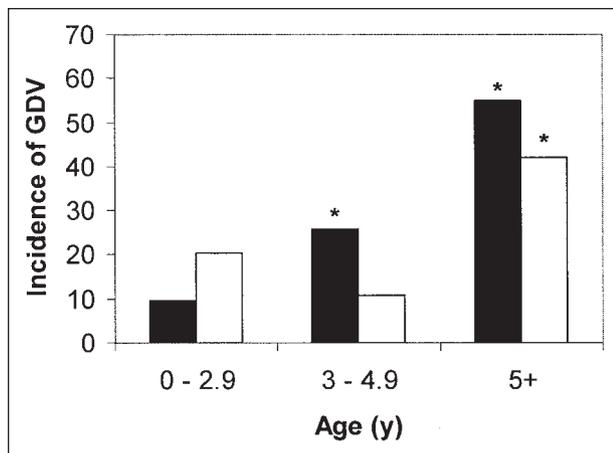


Figure 1—Age-specific incidence (No. of cases/1,000 dog-years at risk) of gastric dilatation-volvulus (GDV) in 1,001 purebred large-breed dogs (23 to 45 kg [50 to 99 lb]; white bars) and 842 purebred giant-breed dogs (> 45 kg [> 99 lb]; black bars). *Significantly different from value for same group at 0 to 2.9 years of age.

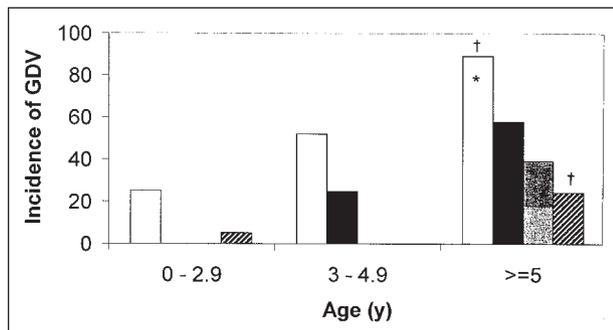


Figure 2—Age-specific incidence of GDV in 4 giant breeds of dogs (Great Dane, open bars; Irish Wolfhound, black bars; Saint Bernard, gray bars; Newfoundland, striped bars). *Significantly different from value for same group at 0 to 2.9 years of age. †Significantly different from values for other groups of the same age.

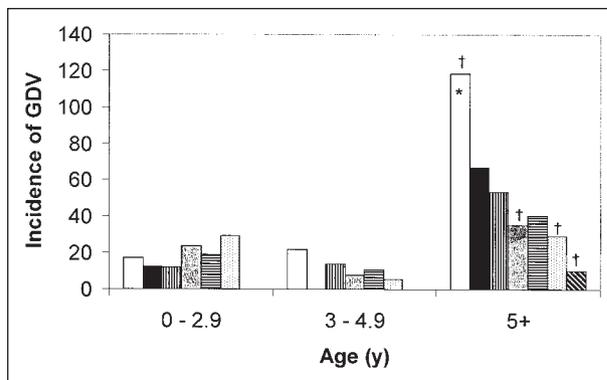


Figure 3—Age-specific incidence of GDV in 7 large breeds of dogs (Bloodhound, white bars; Akita, black bars; Weimaraner; vertical striped bars; Irish Setter, gray bars; Standard Poodle, horizontal striped bars; Collie, dotted bars; Rottweiler, diagonal striped bars). See Figure 2 for key.

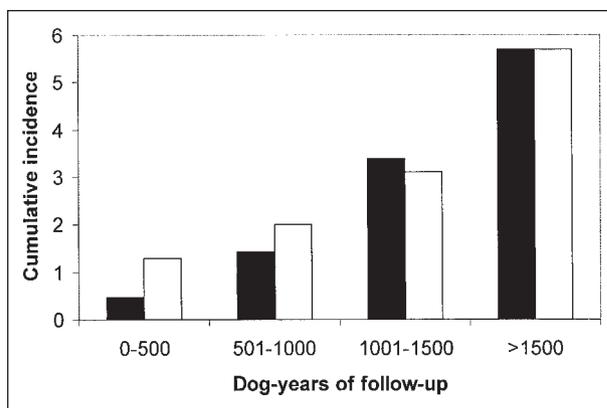


Figure 4—Cumulative incidence (No. of cases/100 dogs) of GDV for 1,001 purebred large- and 842 purebred giant-breed dogs. See Figure 1 for key.

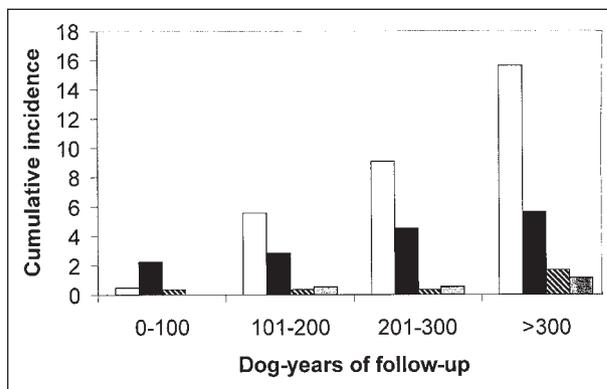


Figure 5—Cumulative incidence (No. of cases/100 dogs) of GDV in 4 giant breeds of dogs. See Figure 2 for key.

ratio and the difference between depth of the thorax and depth of the abdomen. Among female dogs, height was also positively associated with incidence. When these three breed-related conformational characteristics were included in a multiple linear regression analysis, none were significantly associated with incidence of GDV.

Owner-perceived breed-related personality and temperament traits among dogs that were positively

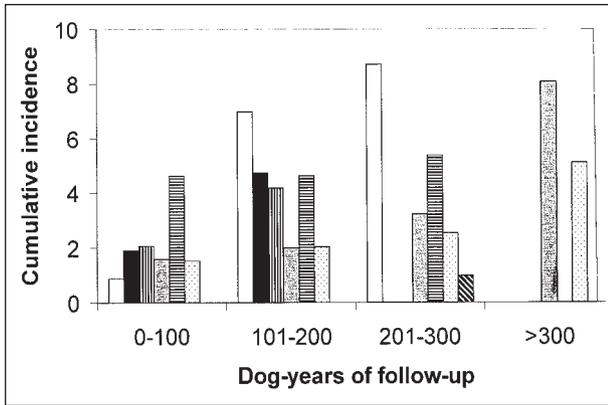


Figure 6—Cumulative incidence (No. of cases/100 dogs) of GDV in 7 large breeds of dogs. See Figure 3 for key.

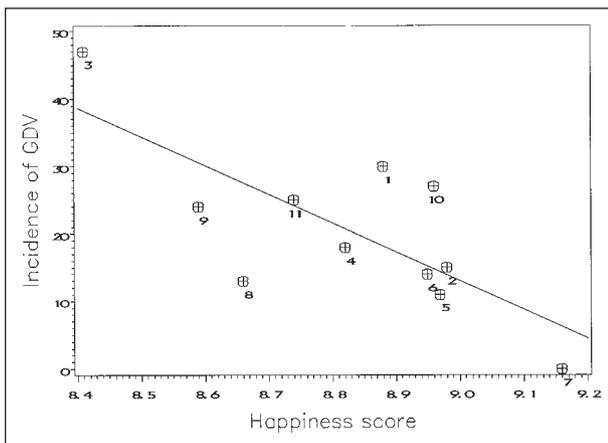


Figure 7—Scatterplot of mean breed-specific incidence of GDV versus mean breed-specific happiness score for male (top graph; $r = 0.69$; $P = 0.02$) and female (bottom graph; $r = 0.74$; $P = 0.01$) large- and giant-breed dogs. Happiness was scored by owners on a scale of 1 to 10, with 1 indicating that dogs never had signs of happiness and 10 indicating that dogs always had signs of happiness. 1 = Bloodhound. 2 = Collie. 3 = Great Dane. 4 = Irish Wolfhound. 5 = Newfoundland. 6 = Standard Poodle. 7 = Rottweiler. 8 = Saint Bernard. 9 = Irish Setter. 10 = Weimaraner. 11 = Akita.

associated ($P < 0.20$) with incidence of GDV by use of univariate linear regression analysis included fearfulness ($r = 0.61$; $P = 0.05$) or agitation in response to strangers or environmental changes ($r = 0.55$; $P = 0.08$), whereas the only trait negatively associated with

incidence of GDV was happiness ($r = -0.79$; $P = 0.004$). When these 3 breed-related personality and temperament traits were included in a multiple linear regression analysis, happiness was associated with a decreased incidence of GDV among male ($P = 0.01$) and female ($P = 0.02$) dogs (Fig 7).

Discussion

Our findings indicate that the likelihood of a purebred large- or giant-breed dog developing GDV during its lifetime is approximately 24 and 21.6%, respectively, assuming the average life span for large- and giant-breed dogs is 10 and 8 years, respectively.¹² Furthermore, the lifetime risk of dying from GDV, given a case fatality rate of 30%, was approximately 7% for these dogs. However, certain breeds, such as the Great Dane, had a higher lifetime risk of developing GDV (42.4%) or dying of GDV (12.6%). These estimates are conservative, because the mean (\pm SD) age of the dogs at the start of this 5-year prospective study was only 3.2 ± 2.5 years, and the incidence of GDV increased with age. Because show dogs are not representative of the pet population in general, it is not possible to accurately estimate the total number of pet dogs that will develop GDV each year. However, GDV is clearly a major cause of morbidity and mortality in large dogs.¹³ Accurate estimates of risk of GDV in specific breeds can help breed clubs and foundations prioritize their research programs and veterinarians effectively disseminate information regarding recognition of early signs of GDV to clients. Moreover, accurate risk estimates can also be useful to veterinarians when counseling dog owners about the risks and benefits of prophylactic gastropexy.

The highest incidence of GDV was observed in 1 of the largest of the breeds in this study, namely the Great Dane. The incidence of GDV in Great Danes was significantly greater, compared with other giant-breed dogs ($P < 0.001$) and large-breed dogs ($P < 0.001$). However, significant associations were not found between mean height and weight of the different breeds and incidence of GDV. Incidence of GDV increased with age in the giant breeds ($\chi^2_{\text{trend}} = 19.9$, $P < 0.001$), which suggested that the pathogenesis of GDV, as for cancer, is somehow tied to the aging process in giant-breed dogs. A similar pattern might also be observed for the large breeds had they been followed for a longer period of time, because large-breed dogs age slower than giant-breeds.¹⁴ In dogs, body size is inversely related to longevity.¹⁴ This implies that the aging process is accelerated in larger dogs, and diseases such as GDV will develop earlier in life in larger dogs, compared with smaller dogs. We found that incidence of GDV in 2 of the giant breeds (Great Dane and Irish Wolfhound) continuously increased with increasing age, whereas in the other giant and large breeds, incidence of GDV did not increase until dogs were older (> 4.9 years).

There may be genetically linked breed characteristics that are related to incidence of GDV, such as conformation and temperament. However, the only interbreed difference we found that was consistently associated with a decreased incidence of GDV was an owner-

perceived personality trait of happiness. Among male and female dogs, as the mean happiness score for a breed increased, incidence of GDV decreased. This does not necessarily mean that within a breed, the happier the dog, the lower its risk of GDV. However, in a recent case-control study,⁴ the risk of GDV in dogs characterized by their owners as happy was reduced by 78%, compared with dogs not characterized as happy. Moreover, risk of GDV was increased by 257% in fearful versus nonfearful dogs. Those authors postulated that physiologic differences between happy and fearful dogs might affect function and motility of the gastrointestinal tract, especially under conditions of acute emotional stress, but they did not discuss the possibility of modifying such personality traits in dogs as part of a GDV prevention program. Measurable differences in personality and temperament between breeds have been described¹⁵ and may partially explain observed differences in incidence of GDV among those breeds.

Our results indicate that it is possible to recruit a large number of dogs and owners for research purposes and to follow the dogs over time to determine disease incidences. However, this type of research requires a great investment of time and effort to achieve high (ie, > 90%) follow-up rates. We believe that a guarantee of confidentiality and a constant dialogue between owners and those conducting the study are important factors that will determine the success of large prospective studies. Communication with owners in the present study was facilitated by setting up an educational exhibit at dog shows, publishing a newsletter for participants, developing an informational Web page, speaking regularly to the participating dog clubs, being available by telephone and e-mail to answer questions, and providing regular telephone and mail contact with owners. Also, intensive efforts were made to locate individuals lost to follow up. This required a full-time staff of dedicated individuals and sufficient funding to sustain the study throughout a 5-year period. The owners in this study were also aware that their parent breed club as well as the Morris Animal Foundation and the American Kennel Club Canine Health Foundation had provided support for the study; this knowledge seemed to further owners' motivation. The enrollment of dogs and owners at dog shows rather than at veterinary clinics may have resulted in recruiting a better informed and more motivated group of owners, because most were already familiar with GDV and had owned or knew of someone who owned a dog that developed GDV.

This report of the Purdue University Prospective Study of GDV described the design and methods. It focused on the incidence and breed-related risk factors. Other reports will attempt to identify characteristics of individual dogs that influence their risk of GDV. Although no single epidemiologic study can by itself prove cause and effect relations, identification of risk factors for GDV will further understanding of the pathogenesis of this disease and be useful for developing effective prevention strategies.

^aPROC Univariate normal, PROC GLM, SAS Institute, Cary, NC.

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