Evaluation of splenectomy as a risk factor for gastric dilatation-volvulus

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Objective—To evaluate whether dogs undergoing splenectomy had an increased risk of gastric dilatation-volvulus (GDV), compared with a control group of dogs undergoing enterotomy.

Design—Retrospective case-control study.

Animals—219 dogs that underwent splenectomy for reasons other than splenic torsion (splenectomy group; n = 172) or enterotomy (control group; 47) without concurrent gastropexy.

Procedures—Medical records were reviewed for information on signalment, date of surgery, durations of surgery and anesthesia, reason for splenectomy, histopathologic findings (if applicable), whether gastropexy was performed, duration of follow-up, and date of death (if applicable). Follow-up information, including occurrence of GDV, was obtained via medical records review and a written client questionnaire.

Results—Reasons for splenectomy included splenic neoplasia, nonneoplastic masses, infarction, traumatic injury, and adhesions to a gossypiboma. Incidence of GDV following surgery was not significantly different between dogs of the splenectomy (14/172 [8.1%]) and control (3/47 [6.4%]) groups. Median time to GDV for the 17 affected dogs was 352 days (range, 12 to 2,368 days) after surgery. Among dogs that underwent splenectomy, sexually intact males had a significantly higher incidence of GDV (4/16) than did castrated males and sexually intact or spayed females (10/156). Incidence of GDV among sexually intact male dogs did not differ between groups.

Conclusions and Clinical Relevance—Results did not support a recommendation for routine use of prophylactic gastropexy in dogs at the time of splenectomy. Other patient-specific risk factors should be assessed prior to recommending this procedure. (J Am Vet Med Assoc 2012;241:461–466)

Gastric dilatation-volvulus is an acutely life-threatening condition primarily affecting large- and giant-breed dogs. The syndrome is characterized by intragastric accumulation of gas, followed by various degrees of gastric volvulus. Increased intragastric pressure, decreased venous return to the heart, and cardiogenic shock ensue. Death commonly and rapidly results when dogs with severe GDV do not receive prompt presurgical intervention. As yet, the exact etiology of GDV is unknown, but specific breed-related and environmental risk factors have been identified. Breeds at highest risk for developing GDV include Great Dane, Gordon Setter, Irish Setter, Weimaraner, Saint Bernard, and Standard Poodle. Glickman et al estimated that the lifetime risk for development of GDV is 24% and 22%, respectively, and determined that the most commonly affected breed is the Great Dane, with a 42% lifetime risk of developing GDV. Gastric dilatation-volvulus is the second leading cause of death in large-breed dogs and carries a case fatality rate of 15% to 33%. Other potential predisposing factors that have been identified include increased thoracic depth-to-width ratio, development of GDV in a first-degree relative (ie, siblings, offspring, or parents), increased age, lean body condition, decreased food particle size, once-daily feeding, increased hepatogastric ligament length, previous splenic torsion and splenectomy, and stress.

The lack of agreement in the veterinary literature regarding the exact etiopathogenesis of GDV is in contrast with findings in human pediatric medicine, in which idiopathic GDV has been strongly correlated with the laxity or agenesia of perigastric (gastrospptic, gastrohepatic, gastrophrenic, and gastrocolic) ligaments. In humans, prophylactic gastropexy has been recommended for patients with agenesis or laxity of these ligaments because an unacceptably high mortality rate (21%) is associated with GDV.

Investigators of several veterinary studies have investigated or proposed perigastric ligament laxity as a predisposing factor in the GDV syndrome. Although it is not currently known whether the increased ligament length is a result of or the cause of GDV, it has been suggested that conditions resulting in stretching and delayed gastric emptying lengthen the gastrosplenic and other perigastric ligaments. Large splenic masses and splenic torsion may similarly cause laxity.

**Abbreviation**

<table>
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<th>GDV</th>
<th>Gastric dilatation-volvulus</th>
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<td>spring, or parents)</td>
<td>increased age, lean body condition, decreased food particle size, once-daily feeding, increased hepatogastric ligament length, previous splenic torsion and splenectomy, stress</td>
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and lengthening.31 Lengthening of the supporting ligaments of the stomach can lead to increased mobility of the stomach within the abdomen.31 If ligamentous laxity predisposes patients to gastric malpositioning, ligament transection such as separation of the gastrosplenic ligament from the stomach during splenectomy may result in a similar condition.

Support for this hypothesis can be found in some clinical reports that have described GDV following splenectomy because of splenic neoplasia27 and splenic torsion18 in dogs. Although the relationship between splenectomy and GDV has not yet been clearly defined in veterinary patients, the authors of several reports18,27,28 have recommended prophylactic gastropexy following splenectomy in dogs. Prophylactic gastropexy in most patients is a routine procedure; however, the associated risks and complications and the added cost to the owner must also be considered. Although complications of prophylactic gastropexy rarely occur when proper techniques are used, they may include intraoperative or postoperative leakage of stomach contents after inadvertent penetration of the gastric mucosa, intraoperative pneumothorax, failure of gastropexy adhesions, and obstruction or delay of gastric outflow.33,34 Additional surgical and anesthetic time needed to perform the gastropexy may increase morbidity in compromised patients.37 Adequate justification for performing prophylactic gastropexy following splenectomy is required before the procedure should be recommended routinely.

We hypothesized that splenectomy and associated transection of the gastrosplenic ligament would be associated with increased risk for development of GDV in dogs, especially in breeds considered to be at high risk for this syndrome. The objective of the study reported here was to determine whether dogs undergoing splenectomy had an increased risk of GDV, compared with a control group of dogs undergoing enterotomy.

Materials and Methods

Case and control selection—Electronic and hard-copy medical records of the Angell Animal Medical Center were searched to identify all dogs that had undergone splenectomy between January 19, 2002, and February 22, 2010. The control group included dogs that had undergone an enterotomy, without splenectomy, between January 12, 2007, and February 19, 2010. Enterotomy was selected as the control surgery because these patients were predominantly healthy dogs with minimal comorbidities that underwent abdominal surgery with surgery and anesthesia durations comparable with those of dogs that had a splenectomy. Dogs were excluded if they had a gastropexy performed prior to or at the time of splenectomy or enterotomy, if they had a gastropexy performed between the time of splenectomy or enterotomy and the time of follow-up, or if required follow-up information could not be obtained from the owners.

Medical records review and owner questionnaire—information obtained from the medical records included breed, sex, body weight, age at the time of surgery, date of surgery, duration of anesthesia, duration of surgery, reason for splenectomy (if performed), whether gastropexy was performed at the time of splenectomy or enterotomy, histopathologic findings (if applicable), duration of follow-up, whether GDV occurred, and date of death (when noted in the medical record). In addition, a written questionnaire was mailed to all owners between April 1 and 30, 2010, to determine whether each dog had undergone prophylactic gastropexy before or after splenectomy or enterotomy, whether the dog developed GDV before or after splenectomy or enterotomy, and the dog’s current status (alive or deceased and date of death if applicable). Dates of any subsequent surgery because of GDV were also obtained.

Statistical analysis—Data were examined graphically, and data that were not normally distributed were transformed prior to analysis. Data are reported as mean ± SD for normally distributed data or median and range for nonparametric data. Statistical comparisons were made with a Student t test for unpaired data, χ2 analysis, or Fisher exact test. A Cox regression analysis was performed to compare the incidence of GDV between the splenectomy and control groups while controlling for differences in age and body weight. The day of surgery was considered day 0 for purposes of follow-up evaluation. Survival analysis was performed via the Kaplan-Meier method and log-rank test. Dogs were censored at death (if no subsequent episode of GDV occurred) or on the last day of follow-up. Statistical analyses were performed with a commercially available software program. Values of P ≤ 0.05 were accepted as significant.

Results

Five-hundred forty-four dogs (405 that underwent splenectomy and 139 that underwent enterotomy) met the initial criteria for study inclusion. Questionnaires were sent to all owners of these dogs. Completed questionnaires were received from owners of 219 dogs (172 in the splenectomy group and 47 in the control [enterotomy] group). Fifty-eight breeds were included in the study. The most common breeds included mixed (n = 31), Labrador Retriever (27), Golden Retriever (19), and German Shepherd Dog (12).

Reasons for splenectomy included histologically confirmed neoplasia (n = 88), nonneoplastic masses (75), infarction (3), splenic injury caused by abdominal trauma (1), and adherence of a gossypiboma to the spleen (1). The owners of 4 dogs declined histologic evaluation of the spleen following surgery.

The splenectomy group consisted of 75 females (68 spayed and 7 sexually intact) and 97 males (81 castrated and 16 sexually intact). The control group comprised 18 females (15 spayed and 3 sexually intact) and 29 males (22 castrated and 7 sexually intact). Sex distribution was not significantly (P = 0.55) different between groups.

Mean age at the time of surgery was 10.3 ± 2.6 years (range, 2.1 to 16.3 years) for the splenectomy group and 4.9 ± 3.5 years (range, 0.3 to 12.7 years) for the control group. Dogs in the splenectomy group were significantly (P < 0.001) older than dogs in the control group. Mean body weight of dogs in the splenectomy and control groups was 28.5 ± 11.7 kg (62.7 ± 25.8 lb; range, 2.7 to...
55.7 kg (60.0 to 122.5 lb) and 22.0 ± 10.52 kg (48.4 ± 23.2 lb; range, 3.8 to 43.8 kg [8.3 to 96.3 lb]), respectively. Dogs in the splenectomy group were significantly (P < 0.001) heavier than dogs in the control group.

None of the dogs had an episode of GDV prior to splenectomy or enterotomy. Gastric dilatation-volvulus developed after surgery in 14 of 172 (8.1%) dogs in the splenectomy group and 3 of 47 (6.4%) dogs in the control group. Results of Cox regression analysis revealed no significant (P = 0.97) difference in the incidence of GDV between the splenectomy and control groups. Breeds of dogs that developed GDV after undergoing splenectomy included mixed (n = 4), Labrador Retriever (2), American Bulldog (2), and German Shepherd Dog, Standard Poodle, English Springer Spaniel, Bichon Frise, Beagle, and Airedale (1 each). Breeds of dogs that developed GDV after surgery in the control group included Labrador Retriever (n = 2) and Standard Schnauzer (1). The incidence of GDV after splenectomy was not significantly greater in any breed, compared with values for the same breed in the control group.

Mean durations of surgery for splenectomy and control groups were 58.3 ± 22.4 minutes (range, 23 to 139 minutes) and 62.1 ± 19.4 minutes (range, 27 to 115 minutes), respectively. No significant (P = 0.26) difference in surgery duration was identified between the 2 groups or between dogs that did and did not have GDV after surgery. Mean durations of anesthesia for the splenectomy and control groups were 105.4 ± 28.3 minutes (range, 30 to 224 minutes) and 103.8 ± 28.2 minutes (range, 60 to 198 minutes), respectively. No significant (P = 0.72) difference in anesthesia duration was identified between groups.

Dogs in the splenectomy and control groups were further categorized on the basis of body weight (≤ 13.6 kg [30 lb], > 13.6 kg but ≤ 27.3 kg [60 lb], > 27.3 kg but ≤ 40.9 kg [90 lb], and > 40.9 kg). Body weight category was not significantly associated with the incidence of GDV after surgery in either group.

Dogs of large and giant breeds for which the lifetime risk for GDV has been reported elsewhere were evaluated in a separate analysis. The splenectomy group comprised 89 large-breed dogs and 2 giant-breed dogs. Large breeds included Labrador Retriever (n = 27), Golden Retriever (19), German Shepherd Dog (12), Standard Poodle (4), American Bulldog (3), Boxer (3), American Pitbull Terrier (3), Rottweiler (3), and Airedale, Akita, Bernese Mountain Dog, Bouvier Des Flandres, Chesapeake Bay Retriever, Doberman Pinscher, English Setter, Greyhound, Irish Setter, Nova Scotia Duck Tolling Retriever, Portuguese Water Dog, Rhodesian Ridgeback, Siberian Husky, Spinone, and Weimaraner (1 each); the giant-breed dogs were a Mastiff and a Great Dane. The control group comprised 22 large-breed dogs and 1 giant-breed dog. Large breeds included Labrador Retriever (n = 8), Golden Retriever (7), Standard Poodle (2), and Rhodesian Ridgeback, pit bull–type dog, Giant Schnauzer, Greater Swiss Mountain Dog, and Doberman Pinscher (1 each). The giant-breed dog was a Mastiff. No significant (P = 0.83) difference in the incidence of GDV after splenectomy was identified for large-breed dogs, compared with large-breed dogs of the control population. The small number of giant-breed dogs in the study population precluded any statistical comparison.

Age of dogs at the time of surgery, surgery duration, and anesthesia duration were not significantly associated with the incidence of GDV in the splenectomy group. Among dogs that underwent splenectomy, sexually intact males had a significantly (P = 0.009) higher incidence of GDV (4/16) than did castrated males and sexually intact or spayed females (10/136). The incidence of GDV among sexually intact male dogs was not significantly (P = 0.27) different between the splenectomy and control groups.

The median follow-up time documented in the medical records for the splenectomy group was 65.5 days (range, 1 to 2,406 days) and that for the control group was 14 days (range, 1 to 1,166 days). Owner questionnaires yielded median follow-up times of 1,577 days (range, 464 to 2,857 days) for the splenectomy group and 740 days (range, 296 to 1,373 days) for the control group. At the time of follow-up via questionnaire, 20 of 172 (11.6%) dogs in the splenectomy group and 42 of 47 (89.4%) dogs in the control group were alive.

The time between surgery and GDV was available for all 17 dogs in which the condition developed. The median interval between surgery and GDV for these dogs was 352 days (range, 12 to 2,368 days).

Histologic evaluation was performed on 168 of 172 spleens of dogs that underwent splenectomy (the owners of 4 dogs declined histologic analysis). Histologic examination results indicated that 88 of 168 (52.4%) dogs had splenic malignancies (hemangiosarcoma [n = 64], spindle cell sarcoma [10], lymphoma [6], histiocytic sarcoma [4], leiomyosarcoma [2], and fibrohistiocytic splenic nodule [2; both grade II/III]). The remaining 80 (47.6%) dogs had benign splenic masses or lesions (benign nodular hyperplasia [n = 45], hematoema [22], extramedullary hematopoiesis [4], infarction [3], myelolipoma [1], lymphoid depletion with histiocytosis [1], adhesions to gossypiboma [1], and traumatic rupture [1]) or no abnormality detected (2). Of dogs that had hemobademen (n = 74), 27 lesions were benign and 47 malignant. The presence of hemobadenet at surgery was not significantly (P = 0.14) associated with occurrence of GDV after surgery.

Median survival time of all dogs that underwent splenectomy was 204 days (range, 3 to 2,368 days). Dogs with benign splenic lesions had a significantly (P < 0.01) longer survival time (median, 654 days [range, 31 to 2,368 days]), compared with dogs in which these lesions were malignant (median, 83 days [range, 3 to 1,947 days]; Figure 1). Survival probabilities for dogs with malignant splenic neoplasia following splenectomy were 18% at 1 year, 10% at 3 years, and 7% at 6 years. Dogs with benign splenic neoplasia had survival probabilities of 83% at 1 year, 44% at 3 years, and 30% at 6 years after splenectomy. Survival times for the control group were not assessed because of the low number of nonsurviving dogs in this group at the time of follow-up.

Overall survival of dogs in the splenectomy group that did or did not have an episode of GDV in the years
following the surgical procedure were compared (Figure 2). Survival probabilities for dogs that had GDV after splenectomy were 64% at 1 year, 21% at 3 years, and 15% at 6 years, whereas those that did not have GDV had survival probabilities of 47% at 1 year, 27% at 3 years, and 20% at 6 years. A log-rank test revealed no significant (P = 0.61) difference in survival times between dogs in these 2 categories.

**Discussion**

In the present study, no significant difference in the incidence of GDV in the years following surgery was detected for dogs that underwent splenectomy, compared with a control group of dogs that underwent enterotomy. Splenectomy and perigastric ligament laxity have been previously suggested to predispose dogs to GDV. Associations between GDV and prior splenectomy because of splenic torsion or splenic neoplasia have also been suggested. Although the incidence of GDV in dogs that underwent splenectomy was not significantly greater than that of control dogs in the present study, all dogs that had a splenectomy at our referral facility because of splenic torsion had a gastropexy performed concurrently on the basis of recommendations by Millis et al.\textsuperscript{18} Previous gastropexy was part of our exclusion criteria; had these dogs not undergone gastropexy and been included in our study, it is possible that the incidence of GDV following splenectomy may have been higher.

In the present study, dogs that underwent splenectomy because of splenic masses or traumatic injury did not have an increased incidence of GDV in the years following surgery, compared with that of dogs in the control group. Thus, results of the present study did not support a recommendation for routine use of prophylactic gastropexy at the time of splenectomy. These findings contradict recommendations given in previous reports\textsuperscript{18,27,28} but are in agreement with findings of another study\textsuperscript{39} in which authors investigated the incidence of GDV following splenectomy in a small group of dogs (n = 37) and concluded that there was no evidence to support the hypothesis that splenectomy increases the incidence of GDV. In that study,\textsuperscript{39} only 1 of 37 dogs had GDV after surgery and GDV did not develop in dogs of the control population. We speculated that the small sample size, limited follow-up (12 months) and method of data collection (survey questionnaire of referring veterinarians) may have affected the reported results. The present study included a larger number of dogs with a longer median follow-up time, and data were collected via medical records review and use of an owner questionnaire, which
may have included events not treated by or reported to the referring veterinarian. The authors of the previous study hypothesized that a 12-month follow-up period after splenectomy was sufficient because most dogs that undergo splenectomy would not survive beyond that time. Although malignant splenic diseases such as hemangiosarcoma have reported 12-month survival rates of only 6.25% to 7%, a longer survival time could be expected for dogs that undergo splenectomy because of benign disease processes. Gastric dilatation-volvulus in dogs after splenectomy has been described in 4 reports and in 3 of the 5 cases, the syndrome developed several months after surgery. This suggests that the effect of splenectomy on development of GDV may have a delayed onset. The median time to GDV following splenectomy in the study reported here was 352 days (range, 12 to 2,368 days), providing evidence of a need for extended follow-up duration. Splenic neoplasia was the most common reason for splenectomy in the present study, with 89 of 168 (52.4%) lesions histologically assessed as malignant, and median survival times were significantly (P < 0.01) shorter for dogs with malignant splenic lesions than for dogs in which these lesions were benign (83 vs 654 days, respectively). As a result, a large proportion of the dogs that underwent splenectomy had short survival times.

Sex distribution was similar between the splenectomy and control groups of the present study. Sexually intact male dogs had a significantly (P = 0.009) higher incidence of GDV after splenectomy than did sexually intact females and neutered dogs of either sex in the splenectomy group, and the incidence of GDV was not significantly different between sexually intact male dogs of the splenectomy and control groups. It is difficult to draw conclusions on the basis of findings for the small number of sexually intact male dogs in the present study, but a relationship between the male sex and GDV has been previously reported.

We attempted to match the splenectomy and control groups with regard to several variables. The sex distribution and mean durations of surgery and anesthesia were similar between groups; however, dogs in the splenectomy group were significantly (P < 0.001) heavier than dogs in the control group. This could potentially be a confounding factor, but to our knowledge, no association between body weight and incidence of GDV has been identified in the present study. Due to various anatomic characteristics, some large- and giant-breed dogs may be predisposed to GDV. When data for large-breed dogs in the present study were analyzed separately, no significant increase in GDV incidence was detected in those that underwent splenectomy, compared with large-breed dogs of the control group. The small number of giant-breed dogs in the study population precluded meaningful statistical comparison. Interestingly, 2 of 3 American Bulldogs that underwent splenectomy subsequently developed GDV. However, the lack of American Bulldogs in the control group as well as the small number of dogs of this breed in the study precluded statistical analysis, and conclusions could not be made regarding an association between splenectomy and GDV in this breed.

In the present study, incidence of GDV was not increased in dogs that underwent splenectomy because of splenic masses or traumatic injury. This study provides data suggesting that splenectomy alone should not be considered a basis for recommendation of prophylactic gastropexy in dogs, and other patient-specific risk factors should be assessed prior to recommending this procedure. Considering the limitations of this retrospective study, further large-scale prospective research is required to confirm these findings.

References

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