Prevalence, type, and importance of splenic diseases in dogs: 1,480 cases (1985–1989)

W. L. Spangler, DVM, PhD, and M. R. Culbertson, DVM, PhD

Summary: *The prevalence data of splenic diseases from 3 sources were studied. Group 1 consisted of a general diagnostic survey of accessions submitted from private veterinary hospitals in California during a period of approximately 4 years and included 1,372 submissions of canine splenic tissue. Group 2 consisted of surgical splenectomy specimens from 92 dogs; the specimens were submitted to the laboratory for gross and histologic evaluation prior to fixation, and a questionnaire was subsequently sent to determine the outcome of the disease. Group 3 was made up of specimens of 105 splenic lesions derived from a large colony of Beagles with complete medical records and records of pathologic findings.*

In this study, splenic hematoma and hyperplastic nodule, not hemangiosarcoma, made up the bulk of splenic lesions. Hemangiosarcoma was the most frequent neoplasm of the canine spleen, but the combined prevalence of all other splenic neoplasms was similar to that of hemangiosarcoma alone. Splenic hematoma and hemangiosarcoma were grossly indistinguishable in most cases. Hyperplastic lymphoid nodules and hematomas of the spleen appeared to represent a continuum. If that finding was correlated with microscopic splenic blood flow, specific causal relationship could be suggested. Prognostically, the live/dead ratio and mean survival of dogs with various splenic lesions differed significantly.

Most clinical reports that specifically consider the canine spleen are concerned with some aspect of neoplasia, and often more specifically, with hemangiosarcoma.[1-5] In a report including hemangiosarcomas in all tissues, the prevalence of canine hemangiosarcoma varied between 0.3 and 1.98%. Among hemangiosarcomas reported, 62% originated in the spleen. This perspective of splenic disease in dogs tends to distort the importance of neoplasia in the canine spleen relative to the prevalence and importance of nonneoplastic splenic diseases.[3,5] Although actual prevalence data concerning specific primary splenic diseases are scant, some publications emphasize hyperplastic (nodular lymphoid hyperplasia) and degenerative (splenic hematoma) lesions.[3,5,6] The purpose of the study reported here was to determine the prevalence of specific splenic diseases in dogs, as well as possible pathogenetic mechanisms for the formation of splenic hematoma.

From the California Veterinary Diagnostics Inc, 3911 W Capitol Ave, West Sacramento, CA 95691.

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Criteria for Selection of Cases

The dogs in this study were allotted to 3 groups. Records of group-1 dogs were derived from retrospective review of computerized pathologic records from a private diagnostic laboratory.[a] The records were searched for diagnoses that included spleen or splenic as part of the diagnostic terminology. A total of 1,372 cases in dogs were retrieved from a period of 50 months (July 1985 to September 1989). These cases represented 1.3% of approximately 124,000 total accessions from all species of animals during that period. The selected cases represented canine surgical/necropsy specimens submitted from veterinary practices distributed throughout California. Representative sections from all fixed materials were selected from individual submissions and prepared for microscopic evaluation. Group-2 dogs consisted of 92 dogs, for which unfixed spleens derived from surgical splenectomy, were submitted to the laboratory for gross and histologic evaluation (follow-up subgroup). Although the specimens from those dogs were part of the spleens considered in group 1, these tissues were examined grossly by one of the authors (WLS), described, measured, and sampled at multiple (minimum of 7) sites from 0.5- to 1-cm serial gross sections obtained from the fresh tissue. Photographs were obtained in many cases. Microscopic evaluation of these specimens was followed by a letter to the submitting veterinarian requesting the specific health status of the animal and any omitted information (eg, age, gender, breed) to

[a]California Veterinary Diagnostics Inc, West Sacramento, Calif.

Table 1—Prevalence of canine splenic lesions by specific diagnosis (group 1)*

Lesion	No.	Percentage
Hyperplastic nodule	306	23
Hemangiosarcoma	137	10
Hematoma	129	10
Hyperplastic nodule/ hematoma	128	10
Accessory spleen	46	3
Siderotic plaque	38	3
Lymphosarcoma	38	3
Diffuse lymphoid hyperplasia	22	2
Leiomyosarcoma	23	2
Undifferentiated sarcoma	23	2
Mixed lymphoid myeloid hyperplasia	17	1
Myeloproliferative disease	17	1
Myeloid metaplasia	15	1
Splenic infarction	14	1
Splenic arterial thrombosis	12	<1
Metastatic carcinoma	11	<1
Myelolipoma	8	<1
Splenic torsion	8	<1
Fibrosarcoma	7	<1
Mast cell tumor	6	<1
Splenitis	6	<1
Metastatic adenocarcinoma	5	<1
Myeloid hyperplasia	5	<1
Plasma cell myeloma	4	<1
Splenic abscess	4	<1
Reticuloendothelial hyperplasia	4	<1
Amyloidosis	3	<1
Multidifferentiated sarcoma (mesenchymoma)	3	<1
Myxosarcoma	2	<1
Hemangioma	2	<1
Osteosarcoma	1	<1
Sinusoidal telangiectasis	2	<1
Necrosis/hemorrhage	2	<1
Splenic fibrosis	2	<1
Capsulitis	2	<1
Capsular mineralization	1	<1
Traumatic rupture	1	<1
Histiocytosis	1	<1
Extramedullary hematopoiesis†	84	6
Congestion†	97	7
Lymphoid atrophy/depletion†	49	4
Hemosiderosis†	20	2
Lymphoid necrosis†	17	1
Splenic necrosis†	4	<1

*Forty-six submissions characterized histologically as normal spleen are excluded from this table. †Represents the diagnosis in the spleen derived from cases in which multiple tissues were submitted for evaluation.

*Table 2—Prevalence of canine splenic lesions by specific diagnosis (group 2)**

Lesion	No.	Percentage
Hemangiosarcoma	22	24
Hyperplastic nodule/hematoma	18	19
Hematoma	18	19
Hyperplastic nodule	6	6
Myeloid metaplasia	5	5
Leiomyosarcoma	4	4
Multidifferentiated sarcoma (mesenchymoma)	4	4
Histiocytic sarcoma	3	3
Lymphosarcoma	3	3
Hemangioma	2	2
Splenic infarction	2	2
Congestion	2	2
Splenic vascular thrombosis	1	1
Fibrosarcoma	1	1
Plasma cell myeloma	1	1
Myxosarcoma	1	1

*Ninety-two individual submissions, 93 diagnoses.

Table 3—Prevalence of splenic disease in Beagles (group 3)*

Lesion	Total	Percentage
Hyperplastic nodule	52	48
Diffuse lymphoreticular hyperplasia	12	11
Hemangiosarcoma	10	9
Lymphosarcoma	7	6
Hyperplastic nodule/hematoma	6	6
Metastatic neoplasia	6	6
Undifferentiated sarcoma	4	4
Myeloid metaplasia	5	4
Lipoma	2	2
Leiomyosarcoma	2	2
Hemangioma	2	2

*Three hundred seventy-four dogs at risk.

statistically evaluate clinical prognostic factors in canine splenic disease. In group-3 dogs, the surgical and necropsy records from a colony of Beagles were reviewed for similar purposes. These dogs were subject animals in a life-time study of chronic exposure to ^{90}strontium or ^{226}radium. In that study,[7] animals were exposed to various doses of radionuclides with various routes of administration and were monitored for life by periodic clinical and radiographic examination as well as by a variety of clinical analytical methods as required by the protocol. Complete necropsy was performed on all (865) dogs. The data concerning splenic diseases in 105 of the dogs were derived from retrospective analysis of the slides and records of pathologic findings, which for the most part were originally generated by the authors.

Information derived from these 3 data sources was tabulated separately. Each of the splenic lesions (diagnoses) was reviewed histologically. The resulting information was then manually entered into a flat data computer file capable of segregating, grouping, and ordering the data for subsequent analysis. The duration of postoperative survival in the group-2 dogs was compared statistically by use of the Mann-Whitney method. Gender proportions were tested by use of the χ^2 method.

Results

Hyperplastic nodules and splenic hematoma were the most often encountered disease conditions among the canine spleens from all 3 data sources considered by this study. Splenic hemangiosarcoma was second in overall prevalence. In our data, the ratio of nonneoplastic to neoplastic disease in the canine spleen (the general diagnostic population) was 3.6:1 (1,039 to 287) in group 1 (Table 1), 1.3:1 (52 to 41) in group 2 (the follow-up subgroup; Table 2), and 2.3:1 (75 to 33) in group 3 (Beagles; Table 3). Splenomegaly resulted from nonneoplastic diseases in 56% of diagnoses (52 of 93) and from splenic neoplastic diseases in 44% (41 of 93) of diagnoses in group 2. Also in group 2, splenomegaly resulting from hyperplastic nodule and hematoma formation accounted for 42 cases (46% of splenic submissions), whereas splenomegaly and splenectomy attribut-

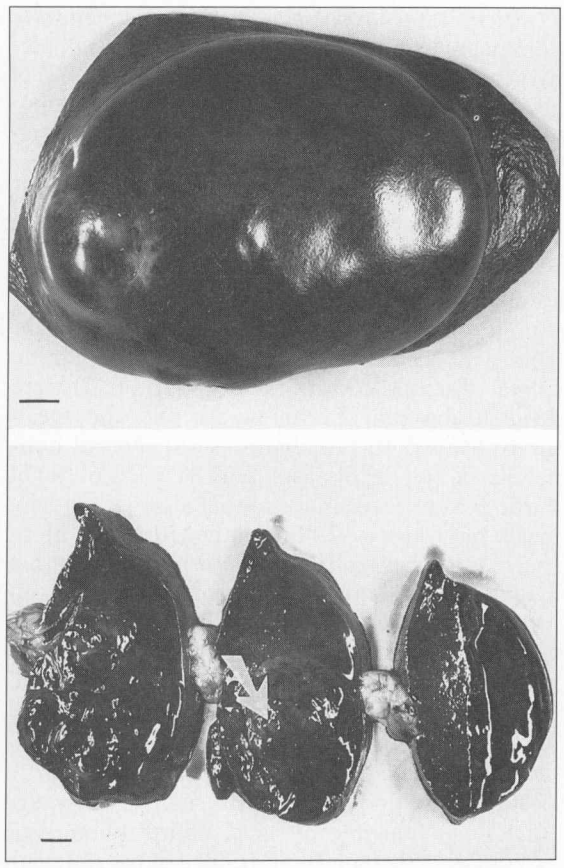

Figure 1—A 10.5-cm subcapsular splenic hematoma (top). Cross sections of a subcapsular hematoma demonstrating a histologically confirmed underlying focus of nodular lymphoid hyperplasia (arrow; bottom). Bar = 1 cm.

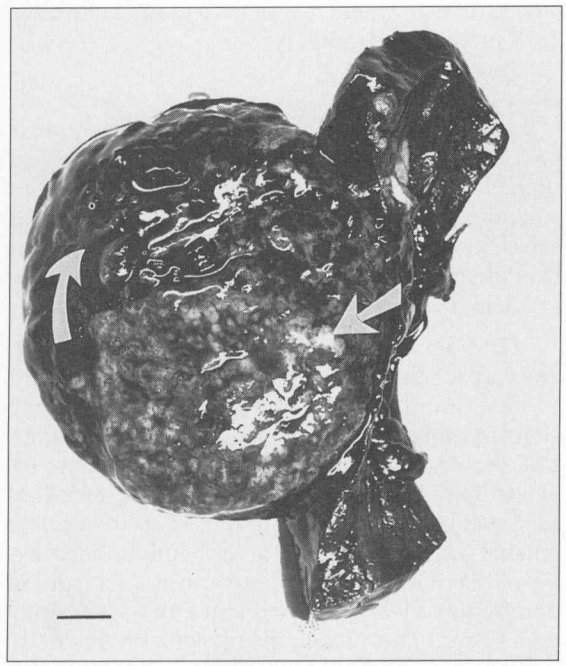

Figure 2—Sectioned surface of a splenic nodule with a discrete area of nodular lymphoid hyperplasia (histologically confirmed; straight arrow) underlying an organizing hematoma (curved arrow); bar = 1 cm.

able to hemangiosarcoma accounted for 22 cases (24% of splenic submissions).

Hyperplastic lymphoid nodules were observed in many specimens in association with splenic hematoma. Macroscopic and microscopic examinations revealed disorganized or compressed lymphoid hyperplastic, or mixed lymphoid-hematopoietic foci along the margins of a splenic nodule consisting of hemorrhage, organizing fibrin, or degenerating erythrocytes (Fig 1 and 2). Similarly, hemorrhagic areas were found within some nodular lymphoid or hematopoietic foci (Fig 3). In some specimens, only erythrocytes or the sequelae of prior hemorrhage (organizing clot) could be detected microscopically (splenic hematoma).

There was no typical gross appearance to reliably distinguish splenic hematoma from hemangiosarcoma and most generally, pathologic features were similar. However, primary hemangiosarcoma of the spleen tended to be multifocal, nodules were individually smaller than hematomas, and most were cavitated with a honeycomb appearance on the sectioned surface. Many of the cavities in hemangiosarcoma contained unclotted blood and resulted in spherical nodules of various sizes, many of which were dimpled or collapsed with a slack or wrinkled overlying splenic capsule, indicating a lack of underlying structural integrity. In contrast, the clotting of blood and subsequent organization tended to give splenic hematomas a firm consistency, producing a nodule that smoothly and firmly distorted the surface of the spleen and one, which on the cut surface, appeared to be compartmentalized or geometrically divided into compartments of various sizes with straight sides or walls made up of connective tissue and with brown discolored irregular areas of necrosis and tissue liquefaction.

The German Shepherd Dog breed ranked first in breed prevalence among the splenic diseases in the categories of hyperplastic nodule/hematoma, hemangiosarcoma, and lymphosarcoma. Golden Retrievers and Labrador Retrievers ranked second and third, respectively, in those categories. An attempt was not made to correct these data for actual breed prevalence in this area. Hyperplastic nodule/hematoma and hemangiosarcoma were found at virtually the same mean age in dogs (10.5 and 10.4 years, respectively) and were evenly distributed between the genders. In group 2, the mean age of dogs with splenic lymphosarcoma was 9.4 years, but the diagnosis of accessory spleen was made at 6.8 years. Myeloid metaplasia/hyperplasia was found in dogs with a mean age of 8.7 years and was found 5 times more often in females than males ($\chi^2 = 6.24$; $P < 0.025$).

Foci of accessory or ectopic splenic tissue represented 3% of splenic lesions submitted to the laboratory (Table 1). These aggregates of viable and identifiable splenic tissue were of various sizes, remote from the spleen, and most were implanted in or attached to the omentum.

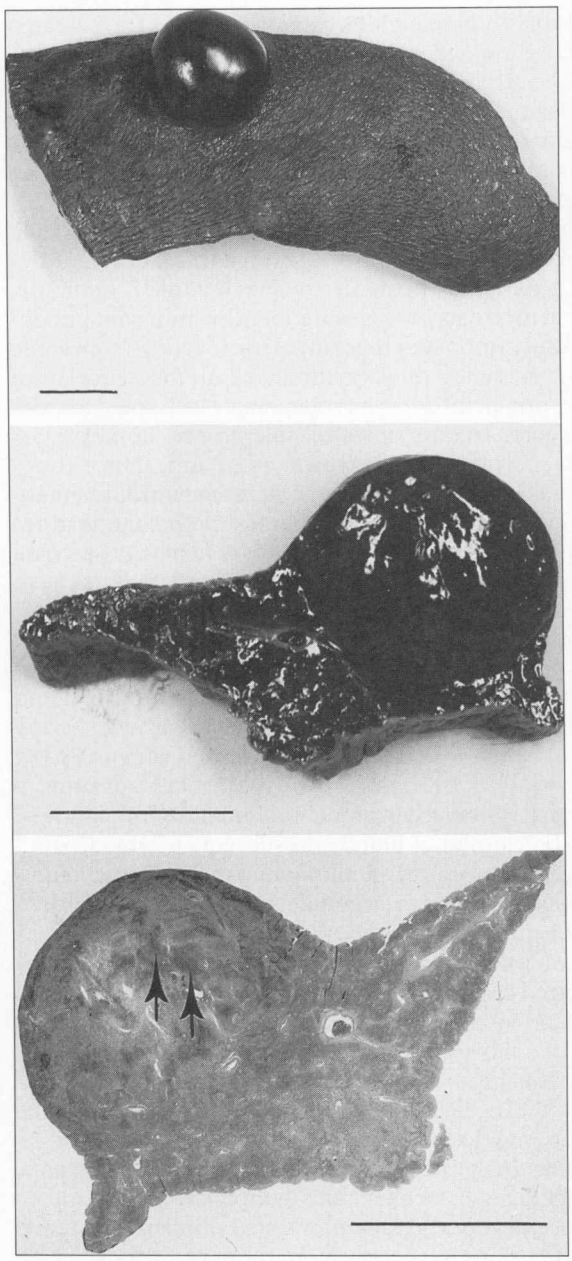

Figure 3—A 1.5-cm single black nodular mass protruding from the parietal surface of the spleen (top). Sectioned surface of splenic nodule in top photograph. The sectioned surface is homogeneous with no distinguishing features (middle). Photomacrograph of section of spleen of a dog. Notice nodular hyperplasia of splenic lymphoid elements with widely dispersed hemorrhages (arrows; bottom). H&E stain; bar = 1 cm.

Myeloid metaplasia/hyperplasia was found as a cause of diffuse, nonnodular splenomegaly in dogs and was characterized by diffuse proliferation of hematopoietic elements at the expense of normal lymphoid follicular and sinusoidal architecture. This proliferation was diffuse throughout the splenic parenchyma, with no organization as discrete hematopoietic foci such as that observed in cases of splenic extramedullary hematopoiesis responding to severe anemia.

Neoplastic disorders of the canine spleen were dominated by hemangiosarcoma in all groups. Hemangiosarcoma accounted for 48% (137 of 287) of all splenic neoplasia in group 1, whereas lymphosarcoma constituted 13% (38 of 287) of the diagnoses in the neoplastic category (Table 1). The remaining 39% (112 of 287) of neoplasms was divided among 13 distinct histologic types.

Definitive survival information was obtained for all but one of the 92 cases in the follow-up survey (group 2). When live/dead ratios were calculated with mean survival times for all neoplastic splenic diseases, 68% of the dogs (28 of 41) were dead at the time of follow-up, and the mean survival was 3.13 months (n = 39). For all nonneoplastic splenic diseases, only 41% (21 of 51) of the dogs were dead at the time of follow-up, and the mean survival was 7.06 months (n = 51). More specific analysis revealed that 82% of dogs with a diagnosis of splenic hemangiosarcoma (18 of 22) were dead at the time of the follow-up (mean survival = 3.02 months), whereas only 37% of dogs with a diagnosis of hyperplastic nodule, hematoma, or both (16 of 41) were dead (mean survival = 7.55 months; $P < 0.001$). These data included all those dogs that died in the immediate postoperative period (0 months survival time). Results for nonangiogenic and nonlymphomatous sarcomas of the spleen were divergent. Although dogs with a diagnosis of splenic fibrosarcoma (1 of 92), leiomyosarcoma (4 of 92), histiocytic sarcoma (3 of 92), and splenic osteosarcoma (1 of 92) were all dead at the time of follow-up (mean survival = 2 months), those dogs with multidifferentiated sarcoma/mesenchymoma (5 of 92) were alive 7.33 months after surgery.

Discussion

Because the spleen is accessible through palpation and radiographic, cytologic, and surgical procedures and because of the high prevalence of splenomegaly detected in this study, we would rank examination of the spleen as an important overall consideration in the practice of veterinary medicine in dogs.

The prevailing perception among veterinarians is that hemangiosarcoma is the most prevalent form of canine splenic disease.[1-4] However, on the basis of more recent surveys,[5,6] and our findings, this perception of splenic disease may require reevaluation. It is only recently that the term hematoma has been used in reference to discrete splenic lesions.[5,6] On the other hand, nodular hyperplasia of lymphoid components is a recognized and frequently encountered lesion in the spleen of aging dogs.[8-10] Although the recognition that hemorrhage may occur in these areas of splenic nodular hyperplasia can be cited, it is anecdotal and not substantiated by numeric or anatomic data.[9,10] The complete pathologic evaluation of large numbers of

spleens (group 2) in this report, in which nodular hyperplastic lymphoid elements were observed with superimposed hematomas, represents convincing anatomic evidence that splenic hyperplastic nodules and splenic hematomas in dogs are related. This association is more strongly supported when the circulatory pattern through the canine spleen is considered.[11,12] A portion of the arterial blood arriving in the spleen through the branches of the follicular arteries enters the reticular spaces of the marginal zone surrounding splenic lymphoid follicules. This blood exits the marginal zone by draining via open-ended venous structures into the sinusoids of the red pulp and finally into collecting veins. It is easy to visualize the consequences of marginal zone distortion resulting from nodular lymphoid hyperplasia with regional disruption of splenic blood flow, failure of marginal zone circulation, and accumulation of blood within and around the hyperplastic nodule eventually leading to hematoma formation, hypoxia, and necrosis.

Although splenic hemangiosarcoma (n = 137) was the second most frequent diagnosis, the prevalence of splenomegaly associated with hyperplastic nodule/hematoma (n = 563) was approximately 4 times greater than hemangiosarcoma in the group-1 dogs (Table 1). In the more limited follow-up series of spleens (group 2), hyperplastic nodule/hematoma and hemangiosarcoma accounted for 45% (42 of 93) and 24% (22 of 93) of diagnoses, respectively; a ratio of 2:1 (Table 2). These observations were primarily responsible for initiation of the complete gross and histologic evaluation of splenic submissions in the group-2 dogs of this study and confirm the relationships between nodular enlargement of the spleen and the prevalence of nonneoplastic nodular splenomegaly. The prevalence of type and class of splenic disease varied in this study on the basis of the sampling method. In the case of the larger general diagnostic survey (group 1), all splenic submissions were combined without regard for the basis of the submission. Included in this segment of the population was a substantial number of multiple tissue submissions derived from necropsy on dogs of diverse ages and dying from a variety of infections or unknown specific causes. Also included in the general diagnostic survey were sections of spleens derived from abnormalities observed during exploratory laparotomy. Many of these were lesions lacking primary disease importance, and therefore, dilute the relative prevalence of primary splenomegaly. On the other hand, the follow-up survey (group 2) consisting entirely of splenectomy specimens is, in some ways, a more accurate representation of the prevalance of specific types of splenic diseases resulting in splenectomy in the general canine population. This conclusion is strengthened to some degree because one pathologist was responsible for gross evaluation and tissue selection from all specimens submitted for evaluation. The Beagle population (group 3) represents data from a tightly controlled population of purebred dogs. These data are most like that observed in group-1 dogs. It should be mentioned, however, that Beagles as a specific breed contributed in a minor way to the overall prevalence of splenic disease and total spleen submissions to the laboratory. This may be the result of a small number of Beagles found in the pet population of this geographic area.

Accessory splenic tissue made up 3% of submissions in the group-1 dogs (46 of 1,326). Although accessory spleen was noticed among group-2 dogs, it was not tabulated because the splenectomy specimen was generally accompanied by a variable amount of omentum, much of which was tightly adhered to the surface of nodular formations in the splenic parenchyma. The reason for the presence of accessory splenic tissue in most cases was obscure. Trauma is a reported cause,[8,13] and on the basis of our observations, fragmentation of splenic nodular lesions may be a major contributing factor. In our specimens, we were consistently unable to grossly distinguish between accessory splenic tissue and the omental implantation of hemangiosarcoma.

We could only find the descriptive pathologic features of myeloid metaplasia/hyperplasia as an unreferenced discussion in a standard pathology text.[14] It was an important cause of splenomegaly and splenectomy in all 3 groups in this study and by this inference, is apparently of clinical importance. A case report of a disease syndrome with striking similarities to these dogs was found.[15] Information in the follow-up survey revealed a lack of positive correlation between myeloid metaplasia and neoplastic myeloproliferative disease involving the spleen. In group-2 dogs, 5 cases of splenic myeloid metaplasia were recorded. Three of the 5 dogs were alive at the time of the survey with a mean survival at that point of 7.7 months (range, 4 to 13 months). One of the dogs was dead with a postmortem diagnosis of myeloproliferative disease, and one of the dogs was lost to follow-up. The gender of the animal was reported for only 13 of the 20 cases of myeloid metaplasia/hyperplasia in group-1 dogs; however, among those reporting, female predominance was significant ($P < 0.025$). In contrast to the group-1 dogs (general diagnostic survey), in group 2 (follow-up subgroup), 4 of the 5 dogs were males, effectively reversing the gender predilection observed previously.

The proportion of hemangiosarcoma to nonangiomatous/nonlymphomatous tumors in our study was 2:1 (group 1), 1.2:1 (group 2), and 1.4:1 (group 3), compared with 4:1 in another study.[16] We found a wide variety of sarcomatous lesions among the dogs in the 3 data groups. The combined prevalence of nonangiomatous/nonlymphomatous sarcomas was similar to that of hemangiosarcoma alone, and these tumors constituted a major cause of splenomegaly, splenectomy, and mortality.

On the basis of our findings, splenic disease is an important clinical consideration in dogs. Pathologic evaluation of specimens submitted because of splenomegaly and other clinical indications for splenectomy are likely to reveal a large nonneoplastic nodular spleen with good prognostic characteristics. The finding of small, red, disseminated intraabdominal masses, when associated with a microscopic diagnosis of splenic hemangiosarcoma, is indicative of a grave prognosis. However, similar lesions of no clinical consequence also can be seen with a diagnosis of splenic hematoma. When survival of the dog is correlated with the type of splenic disease (group 2), a distinctive trend is noticed. These data suggested a markedly different prognosis for canine splenic diseases that are surgically and clinically indistinguishable, emphasizing the importance of careful gross evaluation (by a pathologist, if available) and selection of multiple tissue sections from the interface area between splenic nodules and adjacent splenic parenchyma. The general prognosis for dogs with nodular splenomegaly appears to be better than is generally perceived.

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