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Canine splenic lesions: epidemiological patterns and the predictive value of hemoperitoneum for malignancy

Derick Santana Alves
Universidade Estadual Paulista (Unesp)
Vinícius dos Santos Resende Rodrigues
Universidade Estadual Paulista (Unesp)
Luiz Guilherme Dercore Benevenuto
Universidade Estadual Paulista (Unesp)
Renée Laufer-Amorim
Universidade Estadual Paulista (Unesp)
Carlos Eduardo Fonseca-Alves
carlos.e.alves@unesp.br
Universidade Estadual Paulista (Unesp)

Short Report

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Abstract

Splenic lesions are common in dogs and are frequently associated with suspicion of malignancy. However, the applicability of the traditional “two-thirds rule” across different canine populations remains uncertain. This study aimed to characterize the epidemiological, clinical, and histopathological features of dogs undergoing splenectomy and to investigate hemoperitoneum as a potential indicator of splenic malignancy. Medical records and histopathological reports from 228 dogs submitted to splenectomy between 2008 and 2024 were retrospectively reviewed, comprising 293 splenic lesions. Epidemiological, clinical, ultrasonographic, and histopathological data were analyzed using descriptive and association analyses, and odds ratios (ORs) were calculated. The study population consisted predominantly of middle-aged to older dogs, with a median age of 10 years, large-breed dogs (53.9%), and mixed-breed dogs (50.4%). Non-neoplastic and neoplastic lesions accounted for 50.5% (148/293) and 49.5% (145/293) of diagnoses, respectively. The most frequent diagnoses were hemangiosarcoma (HSA) (n = 72), splenic infarction (n = 32), nodular hyperplasia (n = 24), extramedullary hematopoiesis (n = 23), lymphoma (n = 22), and hematoma (n = 22). Free abdominal fluid was detected ultrasonographically in 76/228 (33.3%) dogs, of which 45 underwent laboratory evaluation of the effusion. Dogs with hemoperitoneum had 4.4 times greater odds of having neoplastic splenic lesions (OR = 4.40; 95% CI: 1.82–10.66) and 11.5 times greater odds of HSA compared with other splenic diagnoses (OR = 11.49; 95% CI: 4.84–27.28). These findings indicate that hemoperitoneum is a clinically relevant indicator of splenic malignancy, particularly HSA, and may aid preoperative risk stratification. The lower neoplasia frequency observed challenges the broad applicability of the traditional “two-thirds rule".

1. Introduction

Splenic lesions are commonly encountered in canine clinical practice, particularly in middle-aged to older dogs, and their differentiation as benign or malignant before surgery remains challenging (Corvera et al. 2024; Ko et al. 2023). Ultrasonography can identify splenic lesions and abdominal effusion but has limited specificity for distinguishing their underlying pathology (Aronsohn et al. 2009). Hemoperitoneum is frequently associated with splenic disease, particularly rupture of hemangiosarcoma (HSA), although it may also occur with non-neoplastic lesions, limiting its diagnostic specificity when considered in isolation (Liuti 2010; De Nardi et al. 2023; Dempsey and Ewing 2011).

The reported frequency of malignant splenic lesions varies among canine populations, and the traditional “two-thirds rule” may not be broadly applicable (Davies and Taylor 2020; Dell'Anno et al. 2026). Comprehensive epidemiological data from South American populations remain limited, and the clinical value of readily available findings such as hemoperitoneum in predicting splenic malignancy has not been extensively characterized.

Therefore, this retrospective study characterized the epidemiological and histopathological features of splenic lesions in dogs undergoing splenectomy at a veterinary referral center over a 16-year period and evaluated the association between hemoperitoneum and splenic malignancy, particularly HSA.

2. Material and Methods

2.1 Study Design and Case Selection

A retrospective observational study was conducted using medical records of dogs submitted to splenectomy between September 2008 and October 2024, retrieved from the archives of the Pathology Service of the School of Veterinary Medicine and Animal Science, São Paulo State University (UNESP), Botucatu, Brazil. Cases were included if complete clinical records and a definitive histopathological diagnosis of the splenic lesion were available. Dogs without histopathological confirmation or with incomplete data were excluded.

Briefly, for histopathological diagnosis, tissue samples were fixed in 10% neutral buffered formalin at the time of collection and routinely embedded in paraffin. Four-micrometer thin sections were stained with hematoxylin and eosin (H&E) and examined under light microscopy for diagnostic assessment by a pathologist. All diagnoses had been established as part of the routine diagnostic workflow prior to data extraction.

2.2 Data Collection

The clinical and epidemiological data collected included age, sex, breed, and body weight. Clinical presentation at admission was reviewed, including the presence or absence of abdominal effusion and the diagnostic classification of the fluid as transudate, modified transudate, or exudate, based on protein concentration, nucleated cell count, and cell types identified on cytological analysis (Dempsey and Ewing 2011). The specific alternative category of hemoperitoneum was defined as a packed red cell volume greater than 10% and a protein concentration greater than 2.5 g/dL.

2.3 Classification of Splenic Lesions

All splenic lesions were classified based on histopathological examination. For analytical purposes, the data were tabulated into lesion frequency groups, divided into: circulatory lesions, infectious and inflammatory lesions, metastatic lesions, neoplastic lesions, and proliferative lesions. This classification strategy was adopted to enable the assessment of clinically relevant distinctions, particularly with regard to malignancy prediction.

2.4 Statistical Analysis

Statistical analyses were performed using Python version 3.12. Descriptive statistics were used to summarize the data, including frequencies, percentages, medians, means, and standard deviations, as appropriate. Since some dogs presented more than one splenic lesion, the unit of analysis was defined according to the variable of interest. For epidemiological variables inherent to the patient, including age, sex, and body size, analyses were conducted at the individual level, ensuring that each animal contributed only once to the dataset. For histopathological characterization, the lesion was considered the unit of analysis. The distribution of continuous variables was assessed using the Shapiro-Wilk test and graphical inspection of histograms and Q-Q plots. Differences in age and body weight across lesion

categories were evaluated using the Kruskal-Wallis test. Associations between categorical variables were assessed using the chi-square test of independence based on contingency tables. Fisher's exact test was employed when expected frequencies below five were observed or when 2 × 2 contingency tables related to the presence of hemoperitoneum and histopathological outcomes of interest were analyzed. The strength of association between hemoperitoneum and histopathological outcomes was estimated using odds ratios (ORs) and their respective 95% confidence intervals (95% CI). ORs were calculated to assess the association between hemoperitoneum and the presence of neoplastic lesions, as well as between hemoperitoneum and the diagnosis of splenic HSA. A significance level of 5% ($p < 0.05$) was adopted for all analyses.

3. Results

3.1 Epidemiological Data

A total of 228 dogs submitted to splenectomy with histopathological diagnosis were included in the study, yielding 293 splenic lesions. The population consisted predominantly of females (57.9%), followed by males (42.1%), with no statistically significant difference between the two groups. When analyzing the association between lesion category and sex, no statistically significant difference was observed, indicating that lesion categories did not vary meaningfully between males and females (Chi-square = 5.89; $p = 0.65$).

Age data were available in 210 medical records and ranged from 3 to 22 years (Fig. 1A), with a median of 10 years, indicating a predominance of middle-aged to older animals. The highest frequency of cases (15%) occurred at 12 years of age. However, no statistically significant difference in age across lesion categories was observed by the Kruskal-Wallis test ($H = 2.30$; $p = 0.68$).

Regarding body size, given the high frequency of mixed-breed dogs, the population was divided according to body weight for analytical purposes: small-to-medium-sized dogs were defined as those weighing up to 20 kg, and large-sized dogs as those weighing more than 20 kg. Large-breed dogs predominated, accounting for the majority of cases (53.9%), while small-to-medium-sized dogs were less frequent (45.6%), and one dog (0.5%) had no weight recorded (Fig. 1B). The association between lesion category and body weight showed a statistically significant difference among groups ($H = 10.55$; $p = 0.03$). However, when the association between lesion category and body size was evaluated, the result obtained (Chi-square = 11.60; $p = 0.17$) indicated no statistically significant difference between the variables analyzed.

A wide variety of breeds was observed, with a predominance of mixed-breed dogs (n = 115; 50.4%), followed by Pit Bull (n = 25; 10.9%), Rottweiler (n = 13; 5.7%), and Poodle (n = 6; 2.6%) (Fig. 1C).

3.2 Histopathological Diagnoses

A total of 293 lesions were obtained from histopathological diagnoses, distributed across different classification categories. Neoplastic lesions were the most frequent, accounting for 49.5% (145/293) of cases, followed by circulatory lesions at 24.9% (73/293) and proliferative lesions at 21.8% (64/293). The 10 most prevalent histopathological diagnoses in our population, comprising 231 cases (78.8%), were: HSA (n = 72), splenic infarction (n = 32), nodular hyperplasia (n = 24), extramedullary hematopoiesis (n = 23), lymphoma (n = 22), hematoma (n = 22), hemangioma (n = 15), congestion (n = 9), white pulp hypoplasia (n = 7), and leiomyosarcoma (n = 5) (Fig. 2).

The number of splenic nodules was determined based on macroscopic description. Among the 228 patients, 76.8% (175/228) had a single splenic lesion, while 18.0% (41/228) had two different types of splenic lesions, and 5.3% (12/228) had three splenic lesions. The details of the histopathological diagnoses are presented in Table 1 in Supplementary File 1.

3.3 Presence of Abdominal Effusion

Data regarding the presence of free abdominal fluid were also collected. Of the 228 dogs, 76 (33.3%) presented with free abdominal fluid on preoperative ultrasonographic examination, 118 (51.8%) had no effusion, and in 34 (14.9%) this information was not recorded in the medical records. Among the 76 dogs with free abdominal fluid, collection and laboratory analysis of the effusion was possible in 45 cases; in 15 cases, the fluid was considered non-drainable (small volume or absence of an acoustic window for drainage), and in the remaining 16 cases, information regarding fluid characterization was unavailable. Therefore, analyses of effusion types and their relationship with histopathological diagnoses were restricted to the 45 cases with available laboratory evaluation (Fig. 3).

The frequency of free abdominal fluid varied across the different histopathological lesion categories. The highest proportions were observed in inflammatory/infectious lesions (63.6%), metastatic lesions (46.2%), and neoplastic lesions (40.9%) (Table 2 in Supplementary File 2). Dogs presenting with fluid specifically classified as hemoperitoneum were 4.4 times more likely to have splenic neoplasia (OR = 4.40; 95% CI: 1.82–10.66; Fisher's exact test, p = 0.0006) (Table 3 in Supplementary File 3).

When comparing cases within the five most prevalent diagnoses that presented fluid classified as exudate, transudate, or hemoperitoneum, hemoperitoneum was observed most frequently in HSA cases (72.4%), whereas the remaining lesions showed a higher occurrence of exudates (Fig. 4).

Additionally, the presence of hemoperitoneum was strongly associated with a diagnosis of HSA, increasing the odds of this diagnosis by approximately 11.5 times compared to all other splenic diagnoses combined (OR = 11.49; 95% CI: 4.84–27.28; Fisher's exact test, p < 0.0001).

4. Discussion

The main finding of this study was the association between hemoperitoneum and malignant splenic lesions, particularly HSA, supporting its potential clinical value as an indicator of malignancy in dogs

undergoing splenectomy. This association may be relevant for preoperative risk stratification in dogs presenting with splenic lesions.

Neoplastic lesions were the most frequently identified histopathological category in our population, followed by circulatory and proliferative lesions, although previous studies have reported a higher frequency of non-neoplastic lesions (Sherwood et al. 2016; Corvera et al. 2024; Ko et al. 2023). This heterogeneity likely reflects differences among study populations and clinical settings. Among neoplasms, HSA was the most frequently diagnosed tumor, consistent with previous reports (Corvera et al. 2024; Dell'Anno et al. 2026; Ko et al. 2023; Schick and Grimes 2023). Splenic lymphoma was the second most frequent neoplasm, and may occur as either a primary or secondary lesion; in a previous study, affected dogs had a mean age of 9.8 years, with mixed-breed dogs, Pit Bulls, and Yorkshire Terriers predominating (Fracácio et al. 2018).

Among the 76 dogs with abdominal effusion, hemoperitoneum was the most frequently characterized effusion type. Importantly, dogs with hemoperitoneum had higher odds of neoplastic splenic lesions (OR = 4.40) and HSA (OR = 11.49). These findings are consistent with previous evidence linking HSA to splenic hemorrhage (Fleming et al. 2018) and extend the clinical relevance of hemoperitoneum to preoperative malignancy risk assessment. Fourthman et al. (2025) reported a low prevalence of recurrent hemoperitoneum following splenectomy for benign splenic tumors, supporting the distinction between hemorrhage associated with benign and malignant splenic disease.

Although the so-called "two-thirds rule" is widely cited — according to which approximately two-thirds of splenic masses in dogs are malignant, and of these, two-thirds correspond to HSA (Davies and Taylor 2020) — the results of the present study demonstrated a neoplasia frequency of 49.5%, a value lower than that traditionally reported. These findings suggest that the probability of a splenic lesion being benign may be higher than estimated by this rule, reinforcing that this concept should not be interpreted as universal or applicable to all clinical scenarios. However, this comparison must be made with caution, as the population evaluated in the present study consisted exclusively of dogs undergoing splenectomy.

This study has several limitations. Its retrospective design and single-center referral population may limit generalizability, while reliance on medical records resulted in missing data for some variables. Detection of abdominal free fluid was based predominantly on ultrasonographic records and may therefore be subject to inter-observer variability. In addition, only a subset of dogs with effusion underwent laboratory characterization. Finally, given the higher likelihood of malignant lesions in animals with multiple splenic lesions (Swanton et al. 2025), this characteristic should be considered when interpreting results related to the frequency and distribution of lesions.

Declarations

Ethics approval

Given the retrospective nature of the study and the anonymity of the patients, no formal consent was required by the local committee (CEUA/FMVZ CIAEP/CONCEA nº 03.0115.2024) .

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5. Competing interest

The authors declare they have no conflicts of interest.

Author Contribution

Derick Alves conducted the primary study, case enumeration, and manuscript drafting. Vinícius Rodrigues performed data analysis and manuscript drafting. Luiz Guilherme Benevenuto contributed to manuscript review. Renée Laufer-Amorim assisted with case enumeration and manuscript review. Carlos Eduardo Fonseca-Alves supervised the study and contributed to manuscript review.

Data Availability

The data supporting the conclusions of this study are available in the article and its Supplementary Information. Further information regarding the included canine population may be requested from the corresponding author.

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Tables

Table 1 Frequency of non-neoplastic and neoplastic lesions according to histopathological examination

Histopathological Diagnosis	n	%
Non-neoplastic	148	50,5
Circulatory lesions		
Splenic infarction	32	10,9
Hematoma	22	7,5
Congestion	9	3,1
Necrosis	9	3,1
Thrombus	1	0,3
Inflammatory/Infectious lesions		
Splenitis	10	3,3
Fungal granuloma	1	0,3
Proliferative lesions		
Nodular hyperplasia	31	10,6
Extramedullary hematopoiesis	23	7,9
White pulp hypoplasia	7	2,4
Myeloid metaplasia	1	0,3
Fibrosis	1	0,3
Splenic atrophy	1	0,3
Neoplastic lesions	145	49,5
Primary neoplastic lesions		
Hemangiosarcoma	72	24,7
Lymphoma	22	7,5
Hemangioma	15	5,1
Leiomyosarcoma	5	1,8
Soft tissue sarcoma	4	1,4
Histiocytic sarcoma	3	1,1
Histiocytoma	3	1,1
Myelolipoma	3	1,1
Fibrosarcoma	2	0,7

Anaplastic sarcoma	1	0,3
Myxoid liposarcoma	1	0,3
Visceral mast cell tumor	1	0,3
Metastatic neoplastic lesions		
Mammary carcinoma metastasis	3	1,1
Transmissible venereal tumor metastasis	3	1,1
Cholangiocarcinoma metastasis	1	0,3
Mast cell tumor metastasis	1	0,3
Melanocytic melanoma metastasis	1	0,3
Amelanotic melanoma metastasis	1	0,3
Osteosarcoma metastasis	1	0,3
Undifferentiated sarcoma metastasis	1	0,3
Soft tissue sarcoma metastasis	1	0,3
TOTAL	**293**	**100%**

Table 2 Contingency table of the association between lesion category and presence of free abdominal fluid

Category	Free fluid absent	Free fluid present	Not reported
Circulatory lesions	38 (52,1%)	20 (27,4%)	15 (20,5%)
Inflammatory/Infectious lesions	4 (36,4%)	7 (63,6%)	0 (0,0%)
Proliferative lesions	41 (64,1%)	13 (20,3%)	10 (15,6%)
Primary neoplastic lesions	63 (47,7%)	54 (40,9%)	15 (11,4%)
Metastatic neoplastic lesions	7 (64,1%)	6 (46,2%)	0 (0,0%)

Table 3 Contingency table of the association between hemoperitoneum and neoplastic lesion.

Hemoperitoneum	Absent	Present
Neoplastic lesions	110 (83,3%)	22 (16,7%)
Non-neoplastic	154 (95,7%)	7 (4,3%)

Figures

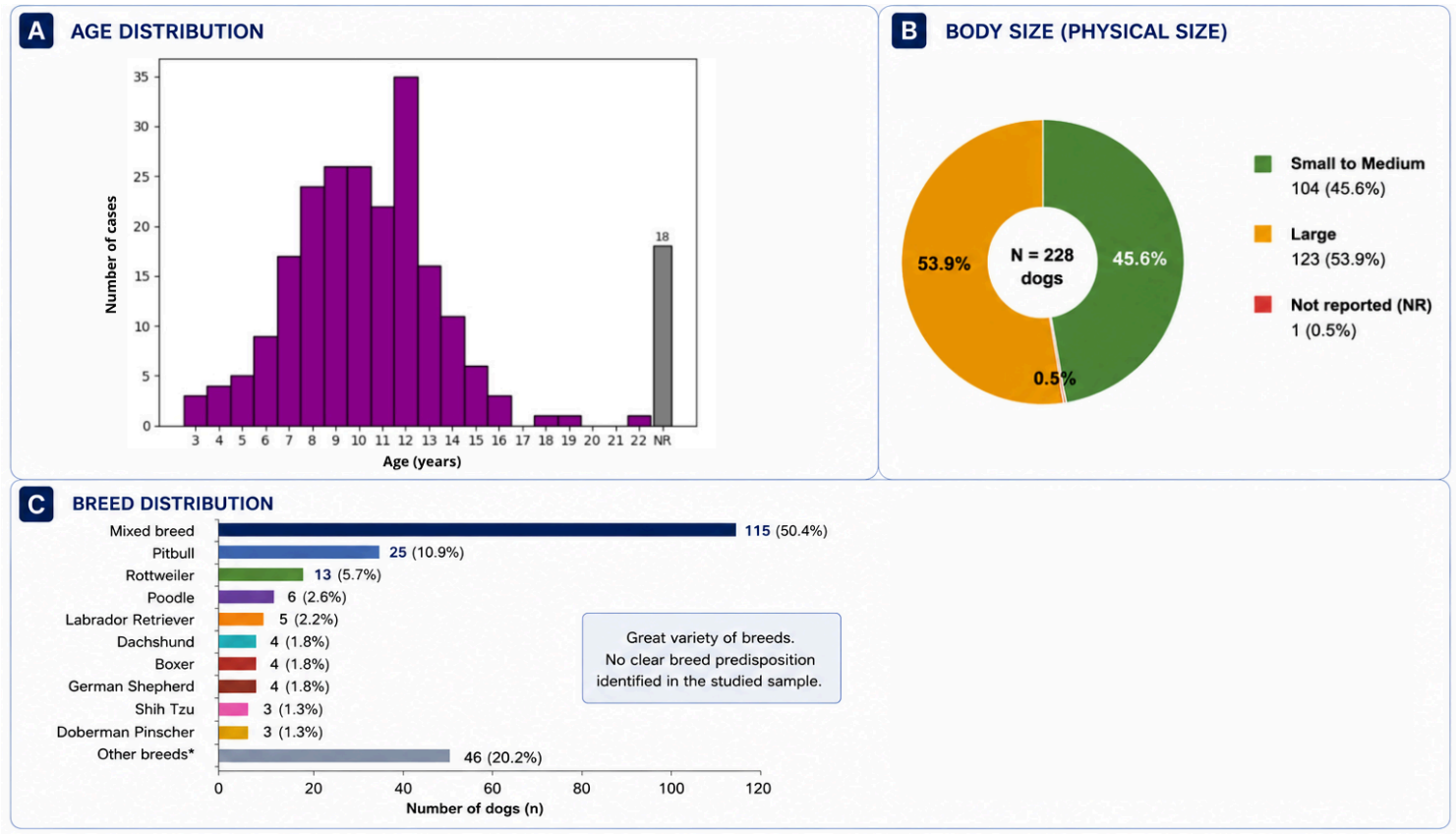


Figure 1

Epidemiological data of 228 dogs undergoing splenectomy with histopathological diagnosis. (a) Age distribution. (b) Distribution according to body size. (c) Distribution according to breed

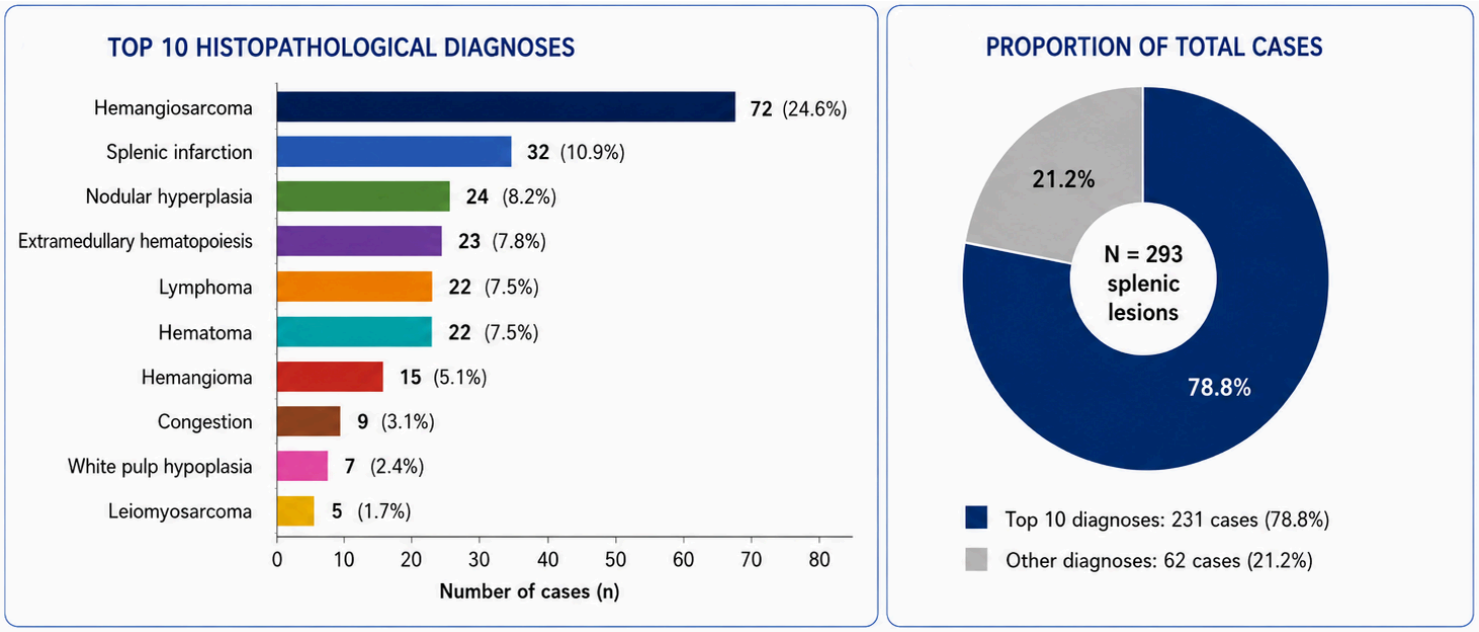


Figure 2

Top 10 most prevalent histopathological diagnoses in 293 splenic lesions from 228 dogs submitted to splenectomy

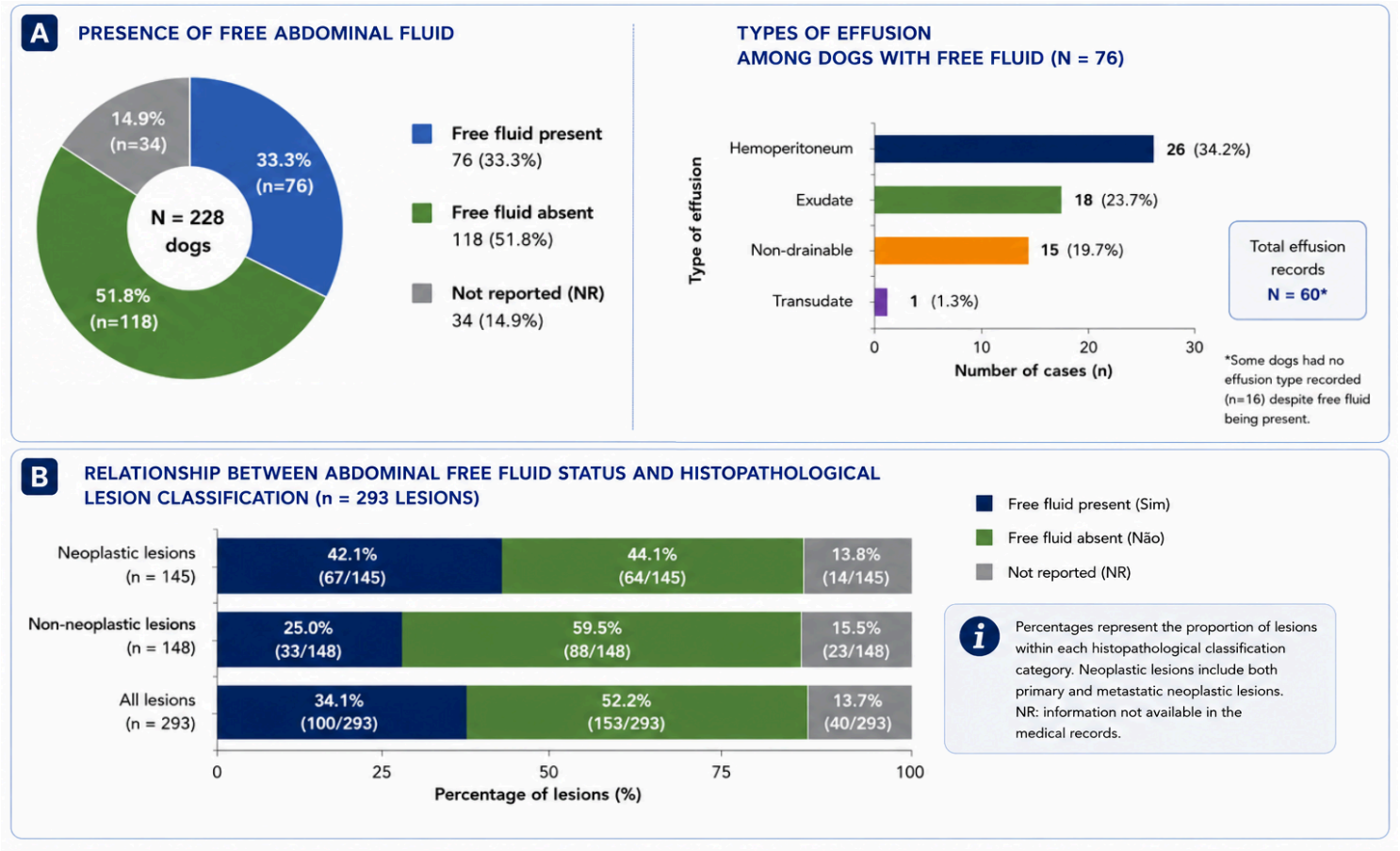


Figure 3

Abdominal free fluid and its relationship with splenic lesion classification in dogs undergoing splenectomy. (a) Free fluid status and effusion types: of the 228 dogs, free fluid was present in 76 (33.3%), absent in 118 (51.8%) and not reported in 34 (14.9%); effusion was characterized in 60 records (26 hemoperitoneums, 18 exudates, 15 non-drainable effusions and 1 transudate). (b) Free fluid by histopathological category (n = 293): it was more frequent in neoplastic (42.1%) than in non-neoplastic lesions (25%)

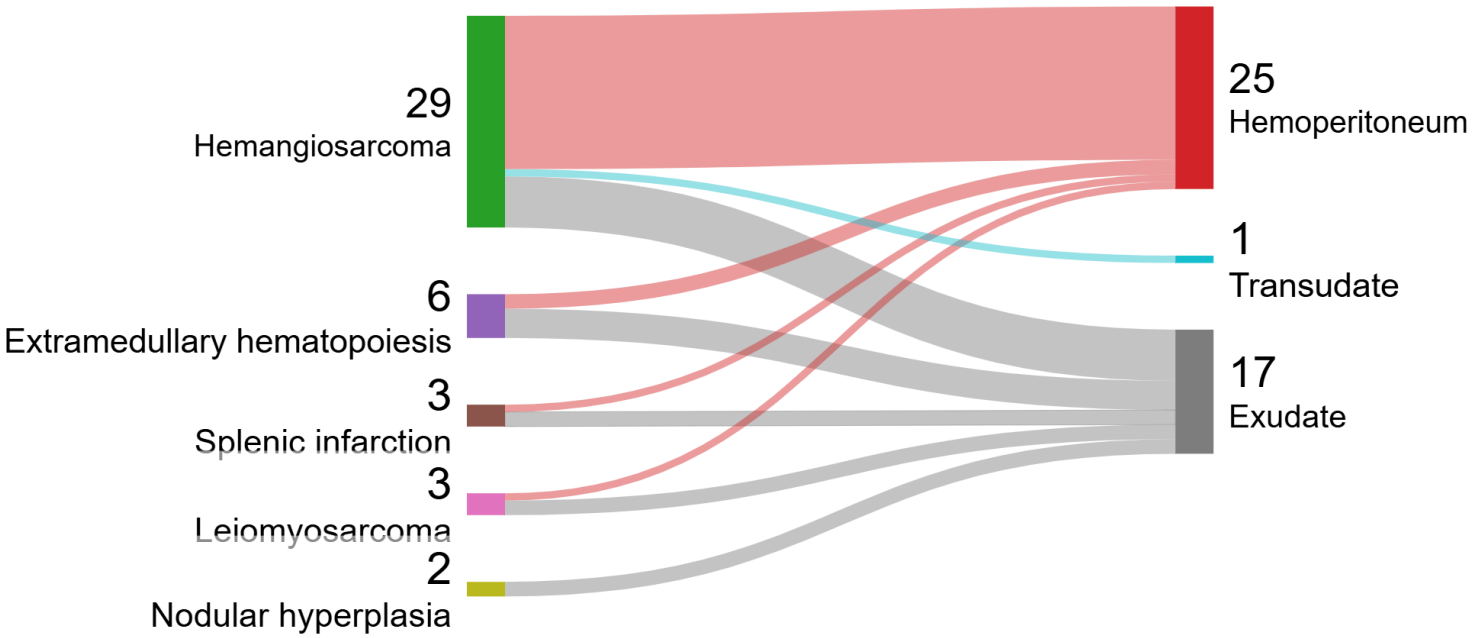


Figure 4

Sankey diagram illustrating the relationship between the five most prevalent splenic diagnoses associated with abdominal effusions and the corresponding effusion types identified in dogs undergoing splenectomy. Hemoperitoneum was most frequently observed in cases of splenic hemangiosarcoma, accounting for 72.4% of all hemorrhagic effusions, whereas the remaining lesions were more commonly associated with exudative effusions. Only one case was classified as transudate, occurring in a dog diagnosed with hemangiosarcoma