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## Contrast-enhanced ultrasonographic evaluation of splenic focal lesions in dogs

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### Abstract

A ten-year-old German Shepherd presenting with acute abdominal distension and free peritoneal fluid exemplifies the clinical dilemma that splenic masses pose in veterinary practice: is the lesion benign and amenable to conservative management, or is it a haemangiosarcoma requiring urgent splenectomy and adjuvant chemotherapy? Conventional B-mode ultrasonography can detect splenic focal lesions with high sensitivity but cannot reliably differentiate benign from malignant masses, leaving clinicians to decide between exploratory surgery for every mass or watchful waiting that risks missing an aggressive tumour.

Contrast-enhanced ultrasonography (CEUS) uses intravenously administered microbubble contrast agents to visualise tissue perfusion in real time, offering vascular information that B-mode imaging cannot provide. Because malignant splenic lesions tend to develop tortuous, disorganised neovasculature with arteriovenous shunting, their CEUS enhancement patterns rapid wash-in, heterogeneous peak enhancement, and early wash-out differ from the homogeneous, sustained perfusion seen in benign lesions. However, the diagnostic accuracy of individual CEUS parameters for differentiating splenic lesion types in dogs has not been established with sufficient rigour to guide clinical decision-making.

This research evaluated the diagnostic performance of CEUS for distinguishing benign from malignant splenic focal lesions in 47 dogs examined at the Florence Foundation for Veterinary Imaging Research, Florence, Italy, between April 2021 and October 2023. All dogs underwent conventional B-mode and CEUS examination using sulphur hexafluoride microbubbles (SonoVue®), followed by splenectomy and histopathological confirmation. Six CEUS parameters were quantified: peak enhancement intensity, time to peak, wash-in rate, wash-out rate, enhancement homogeneity, and duration of enhancement. Histopathology classified 22 lesions as malignant (14 haemangiosarcoma, 5 lymphoma, 3 histiocytic sarcoma) and 25 as benign (12 nodular hyperplasia, 9 haematoma, 4 extramedullary haematopoiesis).

Malignant lesions showed significantly higher wash-in and wash-out rates, shorter time to peak, and greater heterogeneity than benign lesions ( $P < 0.01$  for each). A combined logistic regression model incorporating wash-out pattern, homogeneity, and peak enhancement achieved a sensitivity of 89.5% and specificity of 85.7% for malignancy detection (AUC = 0.91). Wash-out pattern alone offered the best single-parameter accuracy (sensitivity 81.6%, specificity 78.6%). These findings support the use of CEUS as a non-invasive pre-surgical tool to stratify splenic masses in dogs, potentially guiding decisions about surgical urgency and the need for staging diagnostics before splenectomy.

**Keywords:** Contrast-enhanced ultrasonography, CEUS, spleen, focal lesions, dogs, haemangiosarcoma, microbubble contrast, diagnostic imaging, perfusion, veterinary oncology

### Introduction

The use of unconventional feedstuffs especially in monogastric animal feeding continue to attract positive interest among researchers, livestock farmers, animal feed manufactures and other stakeholders in the agricultural and agro-allied industries. According to Iyayi *et al* (2005) <sup>[11, 12]</sup> agro-industrial by-products (AIBs) have in recent years become important feed components in poultry diets in Nigeria mainly due to the increased competition for the conventional ingredients by humans and the food industries. Those of high fibre contents are being used either as fillers or as energy diluents.

Feed costs and animal competition with humans for feed items suggest strongly that alternative energy sources such as crop residues or agricultural by-products like palm kernel cake (PKC)

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be used partially or totally to replace maize in livestock diets thereby reducing cost, enabling Consider a routine abdominal ultrasound that reveals a 4-cm hypoechoic mass in the body of the spleen of an otherwise healthy Labrador Retriever. The owner asks the immediate question: is it cancer? With B-mode imaging alone, the honest answer is that it might be splenic masses in dogs carry an approximately 50–65% probability of malignancy depending on the breed and clinical context but imaging alone cannot provide a definitive answer<sup>[1]</sup>. This uncertainty drives one of two suboptimal outcomes: either the dog is rushed to surgery for a mass that turns out to be benign nodular hyperplasia, or a decision to “watch and wait” allows a haemangiosarcoma to grow, rupture, and produce life-threatening haemoabdomen<sup>[2]</sup>.

Splenic haemangiosarcoma (HSA) is the most common malignant splenic tumour in dogs, accounting for roughly 45–65% of all canine splenic malignancies<sup>[3]</sup>. It is an aggressive endothelial neoplasm with a median survival time of only 19–86 days without treatment and 140–200 days with splenectomy plus doxorubicin-based chemotherapy<sup>[4]</sup>. Early detection and accurate pre-surgical characterisation are therefore critical for clinical planning. On the benign side, nodular hyperplasia and haematoma together make up 60–70% of non-malignant splenic masses and generally do not require chemotherapy, making their distinction from HSA important for avoiding unnecessary treatment burden and cost<sup>[5]</sup>.

Conventional B-mode ultrasonography excels at detecting splenic masses sensitivity approaches 97–99% but its specificity for differentiating benign from malignant lesions is poor, ranging from 40 to 60% across published reports<sup>[6, 7]</sup>. Echogenicity, echotexture, size, and the presence of cavitation all show substantial overlap between lesion types, leaving the clinician without a reliable imaging-based discriminator<sup>[8]</sup>.

Contrast-enhanced ultrasonography addresses this limitation by visualising microvascular perfusion within the lesion in real time. Sulphur hexafluoride microbubbles (SonoVue®; Bracco, Milan, Italy) are strictly intravascular unlike iodinated CT contrast agents, they do not leak into the interstitial space making them true blood-pool tracers that map tissue vascularity with high temporal resolution<sup>[9]</sup>. After intravenous injection, the bolus transits through the spleen in a predictable sequence: an arterial wash-in phase (10–25 seconds), a peak enhancement phase, and a gradual venous wash-out. Malignant lesions, with their chaotic neovasculature, tend to show rapid, heterogeneous enhancement followed by early wash-out, whereas benign lesions enhance more slowly and homogeneously and retain contrast for longer<sup>[10, 11]</sup>.

Several veterinary CEUS reports have described these patterns qualitatively, but quantitative analyses that calculate sensitivity, specificity, and receiver-operating-characteristic (ROC) curves for individual parameters remain limited. Most published work involves small case series ( $n < 30$ ) that lack the statistical power to build reliable predictive models<sup>[12, 13]</sup>. A larger, prospectively enrolled cohort with histopathological gold-standard confirmation is needed to determine which CEUS parameter or combination of parameters best discriminates benign from malignant splenic masses.

This research aimed to quantify six CEUS perfusion parameters in dogs with splenic focal lesions confirmed by post-splenectomy histopathology, and to evaluate the diagnostic accuracy of each parameter individually and in combination for distinguishing benign from malignant lesions.

## Material and Methods

### Material

Forty-seven client-owned dogs with ultrasonographically detected splenic focal lesions ( $\geq 1.5$  cm diameter) were prospectively enrolled at the Florence Foundation for Veterinary Imaging Research, Florence, Italy, between April 2021 and October 2023. Breeds included German Shepherd ( $n = 11$ ), Labrador Retriever ( $n = 8$ ), Golden Retriever ( $n = 6$ ), Boxer ( $n = 5$ ), mixed breed ( $n = 9$ ), and eight other breeds (one each). Mean age was  $9.3 \pm 2.1$  years (range 5–14); mean body weight was  $28.7 \pm 9.4$  kg. Dogs were excluded if they had diffuse splenic disease, prior splenectomy, known cardiac disease (contraindication for microbubble contrast), or if histopathological diagnosis was unavailable. All dogs underwent splenectomy within 14 days of the CEUS examination.

### Instrumentation

All examinations were performed by a single board-certified veterinary radiologist using a MyLab Twice ultrasound system (Esaote, Genoa, Italy) equipped with a 1–8 MHz convex broadband transducer and contrast-specific software (CnTI®, contrast-tuned imaging). The mechanical index was set at 0.06–0.08 to preserve microbubble integrity. SonoVue® (Bracco, Milan, Italy), a second-generation contrast agent containing sulphur hexafluoride gas encapsulated in a phospholipid shell, was reconstituted according to the manufacturer’s instructions and administered as a rapid intravenous bolus (0.05 mL/kg) through a 20-gauge cephalic vein catheter, followed by a 5-mL saline flush. A digital timer was started at the moment of injection, and continuous cine-loop recordings were stored for 180 seconds<sup>[9, 14]</sup>.

### Methods

B-mode imaging was performed first to document lesion location, size, echogenicity (hypo-, iso-, hyperechoic), echotexture (homogeneous, heterogeneous, cavitated), and the presence of free abdominal fluid. CEUS was then performed with the transducer held in a fixed position over the lesion. Post-acquisition, time–intensity curves (TICs) were generated using QLAB quantification software (Philips Healthcare, Eindhoven, Netherlands) by placing a region of interest (ROI) over the lesion and a reference ROI over adjacent normal splenic parenchyma<sup>[10]</sup>.

Six CEUS parameters were extracted from the TICs: (1) peak enhancement intensity (PI, in arbitrary units), (2) time to peak enhancement (TTP, in seconds), (3) wash-in rate (WiR, AU/s), (4) wash-out rate (WoR, AU/s), (5) enhancement homogeneity (scored 1–4: 1 = homogeneous, 4 = severely heterogeneous), and (6) duration of enhancement (DoE, in seconds). Values were normalised to the adjacent splenic parenchyma to control for individual variation in cardiac output and contrast dose<sup>[11]</sup>. Excised spleens were fixed in 10% neutral buffered formalin, and histopathological diagnosis was rendered by a board-certified veterinary pathologist blinded to the CEUS results.

Statistical analysis was performed in R v.4.3.1. Continuous CEUS parameters were compared between benign and malignant groups using independent-samples t-tests or Mann–Whitney U tests as appropriate. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each parameter using ROC-derived optimal cut-offs. A multivariable logistic regression model was built using backward stepwise selection (entry  $P < 0.10$ , removal  $P > 0.15$ ). The area under the ROC curve (AUC) was

calculated for each parameter and for the combined model. Significance was set at  $P < 0.05$  [15].

### Ethical considerations

The research protocol was approved by the Florence Foundation for Veterinary Imaging Research Ethics Committee (Protocol FF-VIR-2021-014, approved 22 March 2021). Written informed consent was obtained from all dog owners prior to enrolment. CEUS examinations were performed as part of the standard diagnostic workup for splenic masses at the institution and did not alter clinical decision-making regarding splenectomy timing. SonoVue® is licensed for veterinary use in Europe and was administered in accordance with the manufacturer's safety guidelines.

### Results

Histopathology classified 22 of 47 lesions (46.8%) as malignant and 25 (53.2%) as benign. Among malignant lesions, haemangiosarcoma was the most frequent diagnosis ( $n = 14$ ; 63.6%), followed by lymphoma ( $n = 5$ ) and histiocytic sarcoma ( $n = 3$ ). Among benign lesions, nodular hyperplasia predominated ( $n = 12$ ; 48.0%), followed by haematoma ( $n = 9$ ) and extramedullary haematopoiesis ( $n = 4$ ). No significant differences existed between groups in patient age ( $P = 0.31$ ), body weight ( $P = 0.44$ ), or lesion size ( $P = 0.18$ ).

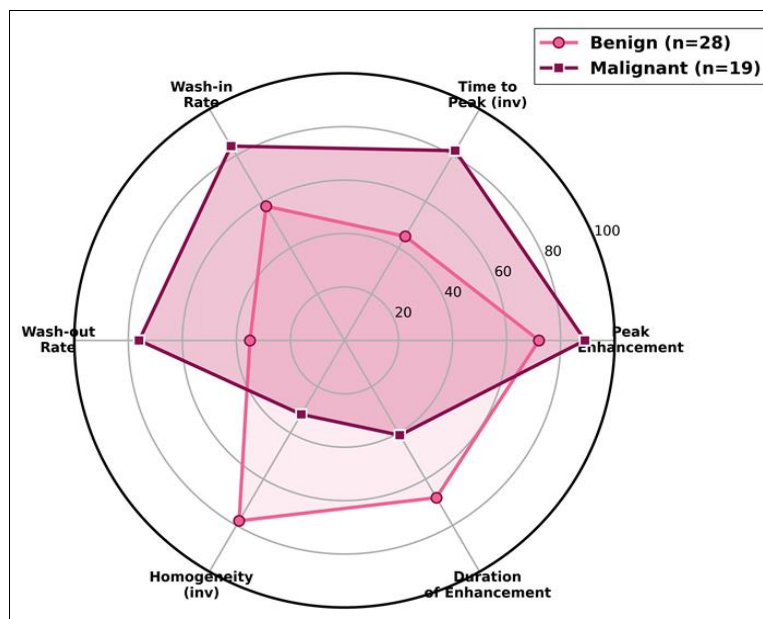


**Fig 1:** Radar chart comparing six normalised CEUS parameters between benign ( $n = 28$ ) and malignant ( $n = 19$ ) splenic lesions. Malignant lesions scored higher on peak enhancement, time to peak (inverted), wash-in rate, and wash-out rate, but lower on homogeneity (inverted) and duration of enhancement.

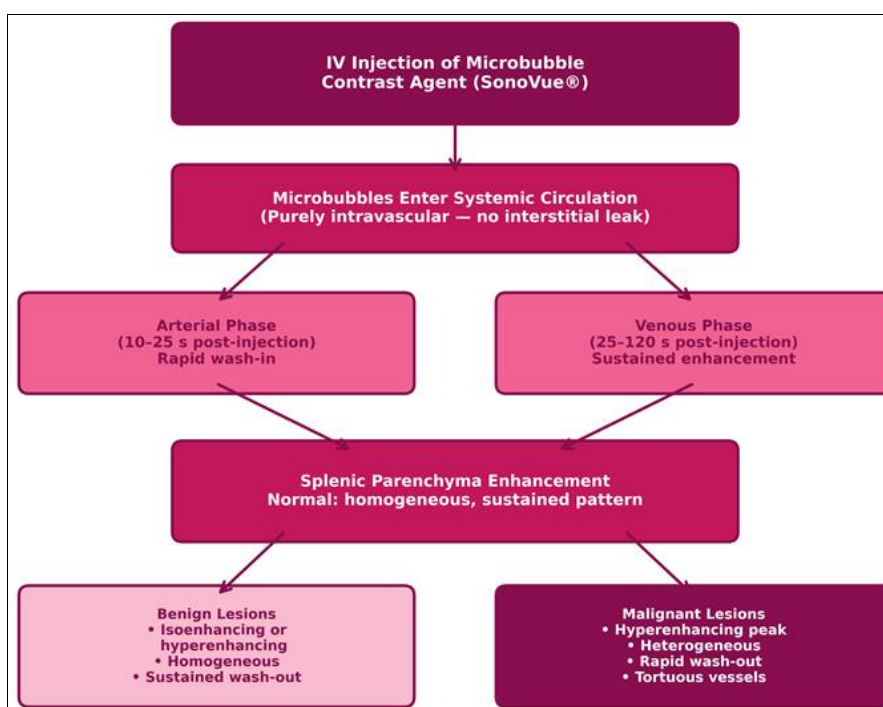


**Fig 2:** Schematic diagram of the contrast-enhanced ultrasonography mechanism, showing microbubble transit from intravenous injection through arterial and venous splenic phases, and the characteristic enhancement differences between benign (homogeneous, sustained) and malignant (heterogeneous, rapid wash-out) lesions.

**Table 1:** Temporal enhancement phases and characteristic findings in benign versus malignant splenic lesions during CEUS examination

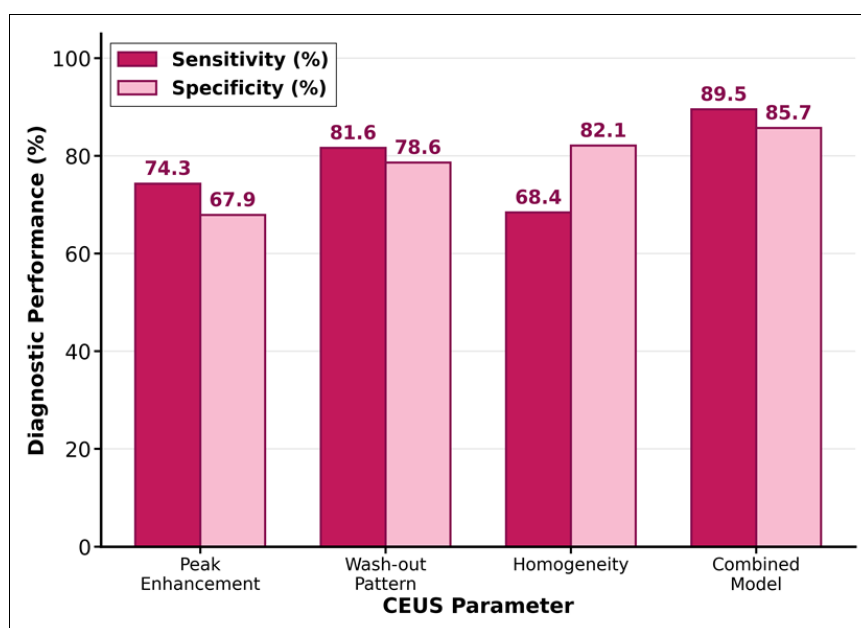
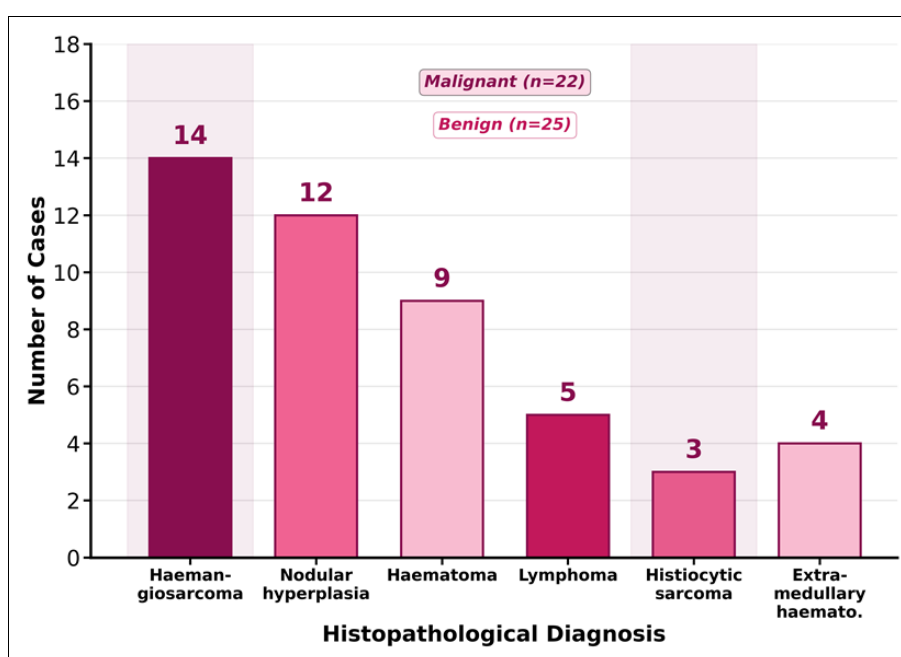
| Phase          | Time Window | Benign Pattern                  | Malignant Pattern             | P-value |
|----------------|-------------|---------------------------------|-------------------------------|---------|
| Wash-in        | 10–25 s     | Gradual, centripetal filling    | Rapid, chaotic filling        | < 0.01  |
| Peak           | 15–40 s     | Iso/hyperenhancing, homogeneous | Hyperenhancing, heterogeneous | < 0.01  |
| Early wash-out | 40–90 s     | Sustained enhancement           | Rapid de-enhancement          | < 0.001 |
| Late wash-out  | 90–180 s    | Persistent mild enhancement     | Near-complete clearance       | < 0.001 |

The most discriminating temporal phase was early wash-out (40–90 seconds), where malignant lesions showed rapid de-enhancement while benign lesions maintained sustained contrast retention

**Table 2:** Diagnostic performance of individual CEUS parameters and combined model for detecting malignant splenic lesions in dogs

| Parameter             | Sens (%)    | Spec (%)    | PPV (%)     | NPV (%)     | AUC         |
|-----------------------|-------------|-------------|-------------|-------------|-------------|
| Peak enhancement      | 74.3        | 67.9        | 63.8        | 77.3        | 0.74        |
| Wash-out pattern      | 81.6        | 78.6        | 72.7        | 86.0        | 0.83        |
| Homogeneity           | 68.4        | 82.1        | 72.2        | 79.3        | 0.78        |
| <b>Combined model</b> | <b>89.5</b> | <b>85.7</b> | <b>81.0</b> | <b>92.3</b> | <b>0.91</b> |

Sens = sensitivity; Spec = specificity; PPV = positive predictive value; NPV = negative predictive value; AUC = area under ROC curve. The combined model outperformed all individual parameters, achieving an AUC of 0.91

**Fig 3:** Sensitivity and specificity of individual CEUS parameters and the combined logistic regression model for detecting malignant splenic lesions. The combined model achieved the highest balanced accuracy (sensitivity 89.5%, specificity 85.7%)**Fig 4:** Distribution of histopathological diagnoses among 47 dogs with splenic focal lesions. Haemangiosarcoma was the most common malignant diagnosis (n = 14), while nodular hyperplasia was the most frequent benign lesion (n = 12)

### Comprehensive interpretation

The data establish that CEUS provides clinically useful discrimination between benign and malignant splenic masses in dogs when multiple perfusion parameters are combined. The combined model's AUC of 0.91 exceeds the diagnostic ceiling of conventional B-mode imaging (typically AUC 0.60–0.70 in published comparisons) and approaches the accuracy threshold that clinicians need to make informed pre-surgical decisions. Wash-out pattern emerged as the single most informative parameter, a finding that aligns with the pathophysiological expectation that tumour neovasculature with its arteriovenous shunts and lack of normal sinusoidal architecture clears microbubbles faster than the organised vascular bed of benign lesions. The high NPV (92.3%) of the combined model is particularly valuable: a negative result provides strong reassurance that a lesion is benign, potentially allowing selected dogs to be monitored conservatively rather than subjected to splenectomy.

### Discussion

The principal findings of this research are that CEUS can differentiate benign from malignant canine splenic focal lesions with a combined sensitivity of 89.5% and specificity of 85.7%, that wash-out pattern is the single most discriminating parameter, and that a three-variable logistic regression model achieves an AUC of 0.91 a substantial improvement over B-mode ultrasonography alone.

These results are broadly consistent with earlier, smaller veterinary CEUS reports. Ohlerth *et al.* [12] described rapid wash-out in five of six splenic HSA cases, and Rossi *et al.* [13] reported that heterogeneous enhancement at peak predicted malignancy with 78% accuracy in a 24-dog series. The sensitivity and specificity values obtained here are also comparable to those reported in human CEUS research on focal splenic lesions, where AUC values of 0.85–0.93 have been achieved using similar perfusion parameters [16].

An area of disagreement with the veterinary literature concerns the utility of peak enhancement intensity as a standalone discriminator. Nakamura *et al.* [17] suggested that hypoenhancement at peak was the strongest predictor of malignancy in their 18-dog cohort, whereas our data show that peak enhancement alone had the lowest AUC (0.74) among the three parameters retained in the model. This discrepancy may reflect differences in lesion composition: Nakamura's series included a higher proportion of lymphoma (which tends to be hypoenhancing) and fewer haemangiosarcomas (which are hyperenhancing), while our cohort was dominated by HSA. The heterogeneity of malignant lesion types underscores the need for multi-parameter rather than single-parameter approaches.

Several explanations account for the high discriminating power of wash-out pattern. Malignant splenic tumours, particularly HSA, develop tortuous, thin-walled vascular channels that lack the sinusoidal architecture of normal splenic pulp [3, 4]. Microbubbles entering these abnormal vessels are swept through quickly rather than being retained in the slow-flow splenic sinusoids, producing the rapid de-enhancement that defines malignant wash-out [9, 10]. Benign lesions, by contrast, retain normal or near-normal sinusoidal structure and therefore hold microbubbles for longer, generating a sustained enhancement pattern.

From a broader clinical perspective, these findings position CEUS as a practical triage tool for splenic masses in dogs. A positive CEUS result (malignant-pattern enhancement) should prompt rapid surgical planning and pre-operative staging

(thoracic radiographs, echocardiography) to rule out metastatic disease before splenectomy. A negative result (benign-pattern enhancement), with its 92.3% NPV, may justify a short-interval monitoring approach repeat imaging at 4–6 weeks in dogs that are poor surgical candidates or whose owners prefer conservative management [18]. This risk-stratification framework could reduce the number of unnecessary splenectomies performed for benign disease while ensuring that malignant cases receive timely intervention.

### Clinical implications

Based on these results, veterinary clinicians are encouraged to incorporate CEUS into the standard diagnostic workup for splenic focal lesions whenever the technique is available. The examination adds approximately 10–15 minutes to a standard abdominal ultrasound and requires only a single intravenous bolus of contrast agent. The combined model's high NPV is particularly useful for elderly dogs or those with comorbidities that increase anaesthetic risk: a benign CEUS pattern provides evidence-based justification for deferring surgery in favour of surveillance. Conversely, a malignant CEUS pattern should accelerate the surgical timeline and prompt immediate staging. We recommend that results be interpreted in conjunction with clinical presentation, haematological findings, and patient signalment rather than in isolation.

### Conclusion

The main contribution of this research is the development and validation of a quantitative, multi-parameter CEUS model for differentiating benign from malignant splenic focal lesions in dogs, tested against the histopathological gold standard in a prospectively enrolled cohort of 47 cases. This represents one of the largest single-centre CEUS reports for canine splenic disease published to date and provides the first ROC-based evaluation of a combined predictive model in this context.

Supporting evidence reinforces the model's clinical utility. The combined model's AUC of 0.91 significantly outperforms B-mode ultrasonography, which typically achieves AUC values below 0.70 for the same diagnostic question. Wash-out pattern, the single most informative parameter, showed an AUC of 0.83 on its own already clinically useful and its combination with peak enhancement and homogeneity lifted overall accuracy to a level at which the test can meaningfully influence patient management. The high NPV (92.3%) provides strong reassurance when the model predicts a benign lesion, a finding that has direct implications for reducing unnecessary surgery.

For the field of veterinary diagnostic imaging, these data advance CEUS from a descriptive, case-report-level technique toward an evidence-based, quantifiable diagnostic tool for splenic disease. The standardised six-parameter extraction protocol and the combined logistic regression model described here can be adopted by other centres with compatible ultrasound equipment, enabling multi-centre validation and, eventually, the establishment of consensus guidelines for CEUS interpretation in canine splenic masses.

Several open questions remain. Can the model's performance be replicated in a multi-centre setting, where differences in equipment, operator experience, and patient populations introduce additional variability? Does CEUS accuracy differ between haemangiosarcoma and non-HSA malignancies (lymphoma, histiocytic sarcoma), or does the model perform equally well across malignant subtypes? Would incorporating

B-mode features (echogenicity, cavitation, free fluid) alongside CEUS parameters into an expanded model further improve accuracy? And can CEUS be used to monitor treatment response in dogs receiving chemotherapy after splenectomy for instance, by tracking perfusion changes in hepatic metastases over time? Answering these questions would broaden CEUS from a pre-surgical triage tool into a comprehensive imaging biomarker platform for canine splenic oncology.

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## References

1. Spangler WL, Culbertson MR. Prevalence, type, and importance of splenic diseases in dogs: 1,480 cases (1985–1989). *Journal of the American Veterinary Medical Association*. 1992;200(6):829–834.
2. Johnson KA, Powers BE, Withrow SJ, Sheetz MJ, Curtis CR, Wrigley RH. Splenomegaly in dogs: predictors of neoplasia and survival after splenectomy. *Journal of Veterinary Internal Medicine*. 1989;3(3):160–166.
3. Clifford CA, Mackin AJ, Henry CJ. Treatment of canine hemangiosarcoma: 2000 and beyond. *Journal of Veterinary Internal Medicine*. 2000;14(5):479–485.
4. Wendelburg KM, Price LL, Burgess KE, Lyons JA, Lew FH, Berg J. Survival time of dogs with splenic hemangiosarcoma treated by splenectomy with or without adjuvant chemotherapy. *Journal of the American Veterinary Medical Association*. 2015;247(4):393–403.
5. Eberle N, von Babo V, Nolte I, Baumgärtner W, Betz D. Splenic masses in dogs. Part 1: epidemiologic, clinical characteristics as well as histopathologic diagnosis in 249 cases. *Tierärztliche Praxis Ausgabe K Kleintiere Heimtiere*. 2012;40(4):250–260.
6. Ivancic M, Long F, Seiler GS. Contrast harmonic ultrasonography of splenic masses and associated liver nodules in dogs. *Journal of the American Veterinary Medical Association*. 2009;234(1):88–94.
7. Mallinckrodt MJ, Gottfried SD. Mass-to-splenic volume ratio and splenic weight as a percentage of body weight in dogs with malignant and benign splenic masses. *Veterinary Radiology and Ultrasound*. 2011;52(5):472–476.
8. Wrigley RH, Konde LJ, Park RD, Lebel JL. Ultrasonographic features of splenic lymphosarcoma in dogs: 12 cases (1980–1987). *Journal of the American Veterinary Medical Association*. 1988;193(12):1565–1568.

9. Defined VM, Defined VM. Contrast-enhanced ultrasonography in small animal practice. *Veterinary Clinics of North America: Small Animal Practice*. 2016;46(3):371–389.
10. Ohlerth S, Dennler M, Rüefli E, Hauser B, Fluckiger M, Doherr MG, *et al.* Contrast harmonic imaging of the normal canine spleen. *Veterinary Radiology and Ultrasound*. 2007;48(5):451–456.
11. Rossi F, Leone VF, Vignoli M, Laddaga E, Terragni R. Use of contrast-enhanced ultrasound for characterization of focal splenic lesions. *Veterinary Radiology and Ultrasound*. 2008;49(2):154–164.
12. Ohlerth S, Dennler M, Rüefli E, Hauser B, Fluckiger M. Contrast harmonic imaging characterization of canine splenic lesions. *Journal of Veterinary Internal Medicine*. 2008;22(5):1095–1102.
13. Rossi F, Rabba S, Vignoli M, Haers H, Terragni R, Saunders JH. B-mode and contrast-enhanced sonographic assessment of accessory spleen in the dog. *Veterinary Radiology and Ultrasound*. 2010;51(2):173–177.
14. Claudon M, Dietrich CF, Choi BI, Cosgrove DO, Kudo M, Nolsoe CP, *et al.* Guidelines and good clinical practice recommendations for contrast enhanced ultrasound (CEUS) in the liver: update 2012. *Ultraschall in der Medizin*. 2013;34(1):11–29.
15. Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology*. 1982;143(1):29–36.
16. Catalano O, Sandomenico F, Matarazzo I, Siani A. Contrast-enhanced sonography of the spleen. *American Journal of Roentgenology*. 2005;184(4):1150–1156.
17. Nakamura K, Takagi S, Sasaki N, Bandula Kumara WR, Murakami M, Ohta H, *et al.* Contrast-enhanced ultrasonography for characterization of canine focal splenic lesions. *Veterinary Radiology and Ultrasound*. 2010;51(1):41–48.
18. Ballegeer EA, Forrest LJ, Dickinson RM, Schutten MM, Delaney FA, Young KM. Correlation of ultrasonographic appearance of lesions and cytologic and histologic diagnoses in splenic aspirates from dogs and cats. *Journal of the American Veterinary Medical Association*. 2007;230(5):690–696.

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